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Status and cost analysis of Sabaki tilapia farming in Saudi Arabia

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Abstract
We conducted a survey to gather data on the current production and operating costs of Sabaki tilapia (*Oreochromis spilurus*) aquaculture in Saudi Arabia. The results show the existence of Sabaki tilapia farming on small, medium, and industrial levels in 2019, with average farm size >10 ha and employing >5 farmworkers throughout the production cycle in polyculture systems. Most farms used significantly more amounts of commercial feed than natural feed. The culture cycle on the surveyed farms was <6 months, with the fish produced sold directly to buyers and regular customers. Most producers were not considering a job change. The primary costs involved in Sabaki tilapia aquaculture production were feed (50.06–69.33%), labor (14.51–20.98%), and fry (5.29–5.81%). The medium- and industrial-level farms showed advantageous profitability.

Keywords Sabaki tilapia · Operation · Saudi Arabia · Survey · Profitability

Introduction

Aquaculture is becoming an essential component for sustainable economic development and food security in the Kingdom of Saudi Arabia (henceforth, Saudi Arabia). Moreover, because of the limitations dictated by the government policies and natural environment, marine fish is more suitable than freshwater fish for aquaculture (Young et al. 2020a).

Saudi Arabia currently produces approximately 72,000 tons of aquaculture; shrimp farming accounts for ~70% in 2018 (Food and Agriculture Organization of the United Nations 2020).

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The primary farmed marine fish species, Sabaki tilapia (*Oreochromis spilurus*), Asian sea bass (*Lates calcarifer*), and gilt-head bream (*Sparus aurata*), have contributed 15,000 tons to Saudi Arabia's total fish production in 2019. Given that the price of Asian sea bass has been declining due to overproduction, and the fingerling source of gilt-head bream depends on imports, the aquaculture of Sabaki tilapia has been gaining popularity (Young et al. 2020b).

In general, the aquaculture industry depends on a combination of natural, human, and capital resources, including fry, broodstock, good-quality water, labor, equipment, land, and infrastructure (Stickney 2005; Bunting 2013). The operating costs of aquaculture are critical in determining the profit margins for producers. Furthermore, the profits of aquaculture are affected by multiple other factors including stocking density, price, fishery production, survival rate, and farming techniques (Tisdell 2012; Lee et al. 2015). There are fixed and variable production costs in aquaculture (Shang 1990). The producers cover the fixed costs of land rental, labor, insurance, loan interest, and depreciation. Variable costs include those of fry, feed, drugs, utilities, maintenance, equipment, pond preparation, part-time labor, and transportation (Huang et al. 2011; Young 2015). Despite the increasing production of Sabaki tilapia in Saudi Arabia, most related research has reported the operation costs for freshwater tilapia in Saudi Arabia (Siddiqui and Al-Harbi 1995; Elhendy and Alzoom 2001; Al-Ghanem et al. 2011). Furthermore, Saudi Arabian tilapia aquaculture faced specific issues, including lack of quality fry, low management expertise, and lack of freshwater (Elhendy and Alzoom 2001; Kitto and Regunathan 2012; Young et al. 2020a). Therefore, we conducted a farm survey that focused on the types of Sabaki tilapia aquaculture practices in Saudi Arabia to better understand the current business situation and operating costs that might limit the Sabaki tilapia aquaculture industry in Saudi Arabia.

Methods

Questionnaire design

A questionnaire was designed based on the previous surveys in the industry (Hartley 2007; Lee et al. 2015; Young 2015). Purposeful sampling was used to select survey participants (Palinkas et al. 2015). The survey was conducted from January to December 2019. A total of 65 Sabaki tilapia aquaculture–related personnel were sampled from all 9 primary aquaculture companies from the Ministry of Environment, Water and Agriculture (Ministry of Environment, Water and Agriculture 2019) in Saudi Arabia. The questionnaires comprised single and multiple choice. Before distributing the formal questionnaire, it was first proofread by reliability test and validity evaluation in order to confirm accurate wordings or prevent possible errors (DeVellis 1991; Lynn 1986). Once the questionnaires were collected, the respondents were directly contacted for clarification in case of any queries to avoid deviation from the standard results. Because all 65 questionnaires were valid, the effective return ratio was 100%. In addition to the primary content in questionnaires, the operating status of aquaculture along with their marketing methods and operating costs were analyzed.

Statistical analyses

After collecting the questionnaire data, responses were subjected to encoding and archiving. Predictive Analytics Software (PASW) 18.0 (IBM, USA) was then used to determine questionnaire reliability and conduct statistical analyses.

Percentile method (frequency distribution)

Frequency distribution statistics were used to describe the percentage distribution of the sample structure and evaluate the consistency of responses. Because the respondents managed operations at different scales, the aquaculture scale and operating systems varied. Therefore, the average proportional costs were listed for three different aquaculture scales: small, medium, and industrial.

Nonparametric method

Significance of response differences was determined using the nonparametric Wilcoxon signed-rank test (Conover and Iman 1981).

Net private profitability

The net private profitability (NPP) of Saudi Arabia's Sabaki tilapia aquaculture industry was analyzed. NPP is defined as the total revenue minus the total operating costs (Lee et al. 2003, 2015). Because expenditures on inputs are required to calculate NPP, the different categories of inputs used in production and their costs were first discussed with the respondents. The respondents were then asked about the inputs applied to production activities, which were labeled as one of two factors: tradable and nontradable. Tradable factors were those that were either exported to earn foreign exchange or domestically used to save foreign exchange, whereas nontradable factors were those inputs that could not be traded and could only be used domestically. The NPPs of each Sabaki tilapia farming system were compared to determine each producer's profitability.

Results

Basic information of respondents

After the PASW 18.0 questionnaire reliability analysis, the questionnaire survey's α value was 0.82. Therefore, the questionnaire showed high reliability. Most respondents were producers, and all surveyed farms were located in Saudi Arabia (Table 1). Note that nearly all (98.5%) respondents produced more than two types of species using either rotational or polyculture methods. The majority of the polyculture species were marine fish and shrimp, particularly white shrimp. Asian sea bass and gilt-head bream accounted for 51.6% and 48.4%, respectively, of the species stocked.

Operational status

Seventy-six percent of producers had farm areas of >25 ha (Table 2). The majority (52.3%) of fish farms hired >20 laborers, and most farms purchased fish fry (Table 2). The culture period for most (53.8%) respondents was <6 months, and the use of commercial feed was significantly higher than that of natural feed (Table 2). The majority of farming production facilities were concrete pond (76.9%), raceway, earth pond, and recirculating aquaculture systems (RAS) (Table 2).

Table 1 Basic information on the 65 respondents to the Sabaki tilapia culture questionnaire

Question	Options	%
1. Position	Producer	87.7
(single choice)	Marketing operator	7.7
	Researcher	4.6
2. Polyculture	Yes	98.5
(single choice)	No	1.5
3. Culture species in polyculture	Marine fish	48.4
(single choice)	Seawater shrimp	51.6

Marketing methods

Almost all (95.4%) of the harvested yield was sold live (Table 3). Buyers (78.5%) were primarily targeted customers, whereas 87.7% of sales were regular customers (Table 3).

Only 10.8% of aquaculture farms surveyed indicated that it would be difficult to identify new customers and only 9.2% of respondents said that it was increasingly difficult to operate (Table 3). Therefore, 87.7% of the respondents did not consider changing their jobs (Table 3). The primary difficulties for managing a farm were increased operating costs (69.2%), price instability (40.0%), and disease outbreaks (38.5%) (Table 3).

There were significant differences between respondents for feed type, approach to processing after harvest, primary customer, and future operations (Tables 2 and 3).

Table 2 Operational status of Sabaki tilapia culture in Saudi Arabia, according to 65 survey respondents from the aquaculture industry

Question	Options	%	Wilcoxon signed-rank test (*P*-value)
1. Farm size	1–10 ha	12.3	
(single choice)	11–15 ha	23.1	
	16–20 ha	7.7	
	21–25 ha	4.6	
	>25 ha	52.3	
2. Number of laborers	1–5 persons	7.7	
(single choice)	6–10 persons	16.9	
	11–to15 persons	10.8	
	16–20 persons	12.3	
	>20 persons	52.3	
3. Fry source	Having	30.8	
(single choice)	Buying	69.2	
4. Culture length	Under 6 months	64.6	
(single choice)	6 months to 1 year	35.4	
5. Type of feed	Commercial feed	95.4	0.001 ***
(single choice)	Natural feed	4.6	
6. Production facilities	Raceway	38.5	
(multiple choice)	Cage	12.3	
	Concrete pond	76.9	
	RAS	23.1	
	Earth pond	36.9	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Table 3 Marketing methods used by Sabaki tilapia culture operations in Saudi Arabia, according to 65 survey respondents from the aquaculture industry

Question	Options	Sample no.	%	Wilcoxon signed-rank test (*P*-value)
1. Processing after harvest (single choice)	Sold live	62	95.4	0.001***
	Self-processed	3	4.6	
2. Primary customer (single choice)	Processor	4	6.2	0.036*
	Wholesaler	8	12.3	
	Restaurant	2	3.1	
	Buyer	51	78.5	
3. Regular customers or new customers? (single choice)	Regular	57	87.7	0.01**
	New	8	12.3	
4. Are new customers hard to find? (single choice)	Yes	7	10.8	0.01**
	No	58	89.2	
5. Are operations increasingly difficult? (single choice)	Yes	6	9.2	0.01**
	No	59	90.8	
6. Have respondents considered changing jobs? (single choice)	Yes	8	12.3	0.01**
	No	57	87.7	
7. Reasons for difficulties (multiple choice)	Operating costs are too high	46	69.2	
	Lack of specific industrial policy	3	4.6	
	Poor farm location	16	24.6	
	Disease problems	25	38.5	
	Competitiveness of imported products	20	30.8	
	Price instability	26	40.0	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

Operating cost analysis

The primary identified costs in the three different farm scales were fry (5.24–5.81%), feed (50.06–69.33%), and labor (14.51–20.98%) (Table 4).

NPP of Sabaki tilapia aquaculture in Saudi Arabia

Based on the NPP analyses, medium- and industrial-scale aquaculture farms were considered highly profitable (Table 5).

Table 4 Annual average proportional costs of Sabaki tilapia culture operations in Saudi Arabia, according to the 65 survey respondents from the aquaculture industry

Items	Small scale (<10 ha)	Medium scale (10–25 ha)	Industrial scale (>25 ha)
1. Fry/fingerling	5.24%	5.81%	5.29%
2. Feed	69.33%	60.36%	50.06%
3. Fertilizer	0.80%	0.65%	0.36%
4. Labor	14.51%	15.66%	20.98%
5. Harvesting and marketing costs	1.23%	2.14%	8.81%
6. Utilities	0.50%	2.95%	4.06%
7. Administrative costs[a]	2.29%	3.92%	3.81%
8. Depreciation	6.1%	8.51%	6.63%

[a] Administrative costs include equipment, medicine, and rent

Table 5 NPP of Sabaki tilapia aquaculture in Saudi Arabia, according to 65 survey respondents from the aquaculture industry

Farm scale	Domestic market prices[a] (US$/kg)	Domestic market prices of tradable[b] (US$/kg)	Domestic market prices of non-tradable[c] (US$/kg)	NPP (US$/kg)
Small scale	2.20	0.87	0.23	1.10
Medium scale	2.56	0.84	0.46	1.26
Industrial scale	3.19	0.76	0.57	1.86

[a] The wholesale price of Sabaki tilapia aquaculture product

[b] Tradable factors are those that are either exported to earn foreign exchange or used domestically to save foreign exchange

[c] Nontradable factors represent those inputs that cannot be traded and can only be used domestically

NPP = a–b–c; NPP > 0, the producers make profits from the production; NPP = 0, the production is at a breakeven point; NPP < 0, the producers face a deficit in the production

Discussion

Survey responses indicated that the primary costs of Sabaki tilapia aquaculture in Saudi Arabia were feed, labor, and fry costs, which are consistent with studies on tilapia aquaculture in Central America (Green et al. 1994; Hartley 2007; Young 2015) and China (Zhang et al. 2016). Similarly, a survey on tilapia aquaculture in The Philippines indicated that fry and labor were substantial costs for the tilapia industry, with interest on capital accounting for >90% of total cost (Pillay and Kutty 2005). Parker (2012) demonstrated that variable costs were proportionally higher than fixed costs in aquaculture. Therefore, feed and fry were the major expenditures in fish farming. Unlike other leading tilapia production countries that were sold to the export market (Prabu et al. 2019), our result indicated that Saudi Arabia Sabaki tilapia product was sold to the domestic market.

Alam et al. (2019) reported that the policies should focus on establishing better training and extension services, which has also been hypothesized to reduce production risk of tilapia farming. Here, difficulties in aquaculture management are primarily attributed to high production costs, price instability, and disease. The industry's current operating conditions were maintaining a profit; therefore, 87.7% of the respondents reported that they would not consider changing jobs because of the high profitability in fish culture and dearth of other highly paid jobs in the same region. Furthermore, certain issues resolved by the government authority established specific industrial policy and development plans for aquaculture (Cardia 2016; Young et al. 2020b), and Sabaki tilapia aquaculture is gaining popularity in Saudi Arabia. Most aquaculture companies in Saudi Arabia are either industrial or large-scale businesses. In developing countries, this is important because the scale of aquaculture operations makes a significant difference. For example, we reported that industrial-scale producers spent less on feed because they could produce feed in their own facilities. By contrast, Zhang et al. (2016) found that small-scale Chinese tilapia producers were economically inefficient. Furthermore, limited environmental factors and higher-cost production facilities were more common for Sabaki tilapia farming in Saudi Arabia.

The NPP analysis is a key concern for farmers' production and decision-making. According to our questionnaire responses, the medium and industrial scales are considered highly profitable, which is consistent with reports on tilapia aquaculture in Honduras (Young 2015)

and inland aquaculture in Taiwan (Lee et al. 2015). Al-Ghanem et al. (2011), Khan et al. (2018), and Chithambaran (2019) suggested aquaponic or polyculture with high profitability; our result reported that 98.5% respondents would apply to polyculture. Hence, our NPP analysis showed higher profitability than previously reported research.

Conclusions

In the Saudi Arabian Sabaki tilapia industry, the majority of aquaculture was in polyculture systems; most farms were > 10 ha and used >5 farmworkers. The fish products were primarily sold to buyers and regular customers. Because the major operating costs in Sabaki tilapia production were reported by respondents as feed, labor, and fry. Furthermore, due to polyculture and lower feed cost, the medium- and industrial-level farms were advantageous. The future policies should focus on cost, marketing, and disease prevention for all producers.

This study described and analyzed the operational status and costs involved in the Sabaki tilapia aquaculture industry in Saudi Arabia; additional research is required to explore the most suitable marketing strategies for the industry.

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Code availability Not applicable.

Data Availability Not applicable.

Declarations

Ethics approval Not applicable.

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Conflict of interest The authors declare no competing interests.

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