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ORIGINAL ARTICLE

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Development of defective fish egg sorting machine with colour sensor for trout facilities

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Abstract

The most important problem at the top of the list faced by trout producers is broken eggs. In this study, a further improved machine that is capable of distinguishing defective eggs from good ones with colour sensors is developed. The most important parts for the machine's operation are the colour sensor, a vertically rotating CD-like disk, a water spray valve, and a motor-pump to reuse the used water in the system. The process of separating robust and defective eggs from their own chambers uses a simple motor-driven spraying valve that produces a water gun level pressure. The water that these valves require is circulating within the system. Since the device uses a simple motor-pump and the PLC connected to the sensors draws low electrical currents, the energy consumption is also very low. The improved device has been tested in a trout production facility with a production capacity of 499 tons/year and has been observed to be successfully distinguishing the eggs.

KEYWORDS
defective eggs, egg sorting machine, fish eggs

1 | INTRODUCTION

Consumers are demanding more healthy, high quality, natural, and fresh fish products (Anonymous, 2007; Güler, Zengin, Çakmak, & Aktumsek, 2017), so fish oils containing essential fatty acids and polyunsaturated fatty acids are important for human health (Ateş, et al., 2013). It is known that rainbow trout (*Oncorhynchus mykiss*) is very important species and widely consumed in Europe (Çaklı, Klınıç, Dinçer, & Tolasa, 2006) and cultivated intense in various countries (Fallah, Saei-Dehkordi, & Nematollahi, 2011; Gall & Crandell, 1992; Gökoğlu, Yerlikaya, & Cengiz, 2004; Mashaie, 2001).

For trout farms the most important factor in a quality production is quality eggs (Bromage et al., 1992) and many researchers have undertaken studies to determine the egg quality (Aegerter & Jalabert, 2004; Lahnsteiner, 2000, 2007; Lahnsteiner, Weismann, & Patzner, 1999; Mansour, Lahnsteiner, & Patzner, 2007). It is generally known that factors such as genetics, water temperature, and handling after egg-laying are decreasing the quality (Izquierdo, Fernandez-Palacios, & Tacon, 2001; Schreck, Contreras-Sanchez, & Fitzpatrick, 2001). In order to obtain better quality and more egg, some producers use photoperiod manipulation to breeding fish and triploided eggs (Piferrer et al., 2009). Economically, the presence of defective eggs in the incubation cabinet during the egg opening period negatively affects other fertilized eggs (Wilcox, Stoss, & Donaldson, 1984; Wojtczak et al., 2004), thus, the use of mechanized devices has become a necessity in trout production. Mechanized devices are personalized for many sectors as supporting apparatus. The most important mission of these devices is to make the work that many people can do together in a shorter time and more smoothly. Fish hatchery workers suffer considerable difficulties in sorting out defective eggs, especially at the time of egg fertilization. Therefore, they have been in need for new methods to overcome this issue. In this context, the main purpose of this study is to (a) Being mechanized: To make the process of sorting the eggs fast and practical. (b) Safe time: An egg tray with a total of 4,000 eggs 20% of which are defective takes an hour with an experienced staff to remove the defective eggs (this period does not include the staff's rest time). With this device, it could be possible to sort out hundreds of eggs in a 1-min period. (c) Increasing the Egg Opening Rate: Improve the survivability

of eggs by avoiding contamination due to dead eggs. As a result, the developed device will contribute to the sustainability of healthy fish breeds more efficiently to the fishing facilities sector.

2 | MATERIALS AND METHODS

2.1 | Fish egg

The machine tested with rainbow trout (*O. mykiss*) eggs in a cage fish farm (LBG Trout Farm) located on Hirfanlı Dam (Kırşehir Turkey) in November 2017. The diameter of eggs were between 6 and 7 mm.

2.2 | Programmable control device

Programmable control device (PLC) is one of the most important parts that works in harmony with the data processed by the sensor.

2.3 | Colour sensor

Colour sensor is a sensor that distinguishes colours that are encoded. In this study the colour sensor was used because the egg should not be touched during operation and the response time of colour sensor is short and it can also be used in transparent or reflective objects. Before using with real eggs, colour sensor was scaled with egg size small beads in different colours (red and white). Figure 4a shows the colour sensor together with the fibre optic cable.

2.4 | Disk

A vertically rotating CD-like disk shown in Figure 3a. The disk was obtained with a Computer Numerical Control (CNC) machine. The diameter of the disk used on the device is designed according to the different prepared egg (5.5 mm/6.5 mm/7.5 mm).

2.5 | Motor-pump and spray valve

For the separating robust and defective eggs from their own chambers, a simple motor-driven spraying valve was used which produces a water gun level water-pressure. Required water for system was circulated within the machine.

2.6 | System energy information

The system works with 220-volt city current. One-hour test phase of machine in trout farm, the water temperature of recirculated system was initially 12□ and this was changed ±1□ during the egg sorting period.

2.7 | General working principle

The machine starts with the placement of all the eggs in the disk, rotating for a certain period in the system by shifting the eggs into A- egg entrance, which is shown in the Figure 1. When the system detects that many of the egg holes in the disk are filled, it starts to work automatically. Figure 2 demonstrates the clearest comprehension of the working principle; the rear view of the disk structure clearly shows how the device behaves when it is operating. If the colour is not matt, i.e., if the egg is solid, then it is immediately sprayed through the water spray valve 1 (shown in Figure 2) and sent to the solid egg reservoir. If the colour of the egg is matt, system understand that it is a defective egg. Therefore, the water spray valve does not activate and the egg moves until the pipe area of valve number 2. The defective egg at this spot is sprayed again by the water spray valve and goes to the damaged egg reservoir. This way, the robust and defective eggs separate from each other and the water to be used by the valves in the system is moved by a recirculation system into a single tank (5-L capacity) and the same water is used again by the motor-pump.

The disk system in which the eggs are placed by pouring and the image of the disk mould mounted on the system are given in Figure 3a. The CNC workbench has been utilized in forming the mould. The system was made in dimensions of 1×0.6 m so that it can easily fit into narrow spaces such as hatcheries.

The panel with the PLC, sensors, and other electronic components of the device is given in Figure 4b. Figure 5a shows the rear view of the disk mould and the egg reservoir while Figure 5b shows

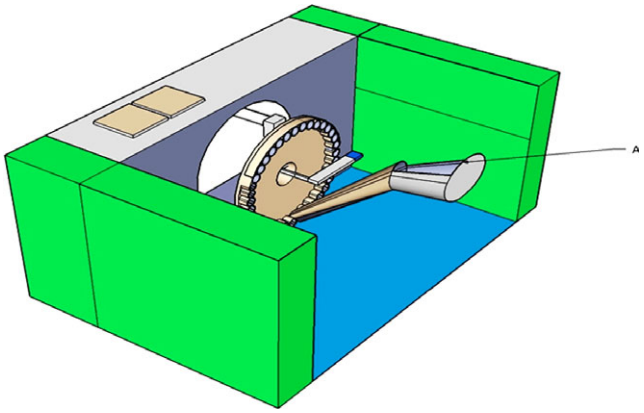

FIGURE 1 Front view of the operating system. A-egg entrance [Colour figure can be viewed at wileyonlinelibrary.com]

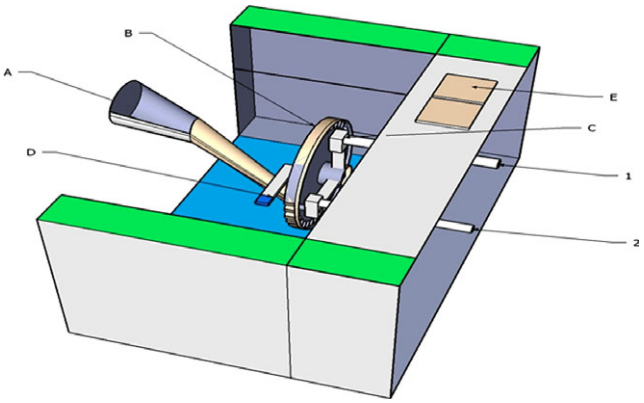

FIGURE 2 Bird view of the operating system. A, Egg entrance; B, Egg holders; C, Color sensor; D, Spray valve; E, On-off; 1 and 2, Spray valves [Colour figure can be viewed at wileyonlinelibrary.com]

FIGURE 3 (a) Disk system in which the eggs are poured. (b) The skeleton of the device as an unmounted structure [Colour figure can be viewed at wileyonlinelibrary.com]

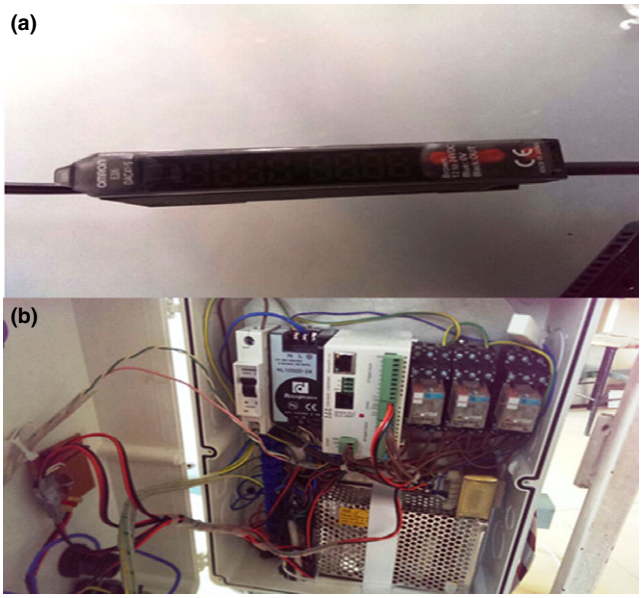

FIGURE 4 (a) Color sensor with fiber optic cable. (b) Panel with PLC, sensors and other electronic components [Colour figure can be viewed at wileyonlinelibrary.com]

the front view of the disk mould and the egg reservoir. Running state of the whole device is shown in Figure 6.

3 | RESULTS AND DISCUSSION

Trout production has been done in Europe since 1950s (Fazio, Saoca, Piccione, & Acar, 2016) and aquaculture is increasing in the world rapidly (Shahrooz et al., 2018). The prevalence of embryonic development in production is also known (Alp & Kamalak, 2010). For this reason, the prototype of this device was tested for both real egg in trout farm and plastic beads of different colours in laboratory

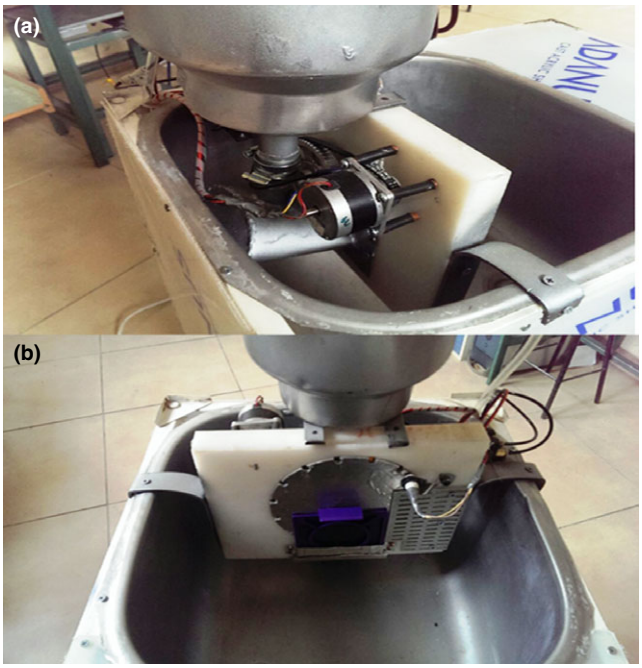

FIGURE 5 (a) Rear view of the chamber and disc mold into which the eggs are poured. (b) Front view of the chamber and disc mold into which the eggs are poured [Colour figure can be viewed at wileyonlinelibrary.com]

FIGURE 6 The whole view of the device [Colour figure can be viewed at wileyonlinelibrary.com]

conditions. It has been observed that the machine which has been tested is capable of distinguishing the real eggs and plastic beads quickly with 100% accuracy. The only problem that needs to be improved in relation to the machine is the necessity of disk changing when it comes to eggs with different diameters. However, since the eggs tested in the same period were in the same hatchery cabinet table, there was no problem stemmed from the difference in egg diameters.

This study shows that an important problem of the trout producers about egg sorting, can be solved with simple mechanical device. As of right now, the distinguishing process of defective egg trout is manually done with human power. For this reason, it is also obvious that the producers spend extra time and workforce to distinguish the defective eggs. It is both time consuming and not efficient

enough to manually remove broken eggs with systems designed with pipette or tweezers. With the improving of the prototype shared in this study, facilities will be able to sort the defective eggs in a fast and effective manner. In addition, it will be possible to prevent the high levels of deterioration of the eggs, which is resulting from the systems with pipette or hand-selection.

In the market there are some sorting machines working with different technologies. Some of them use image processing camera and others are using different sorting technics such as photocell. Although the prices of these machines in the market range from $5,000 to $50,000 the cost price of machine developed in this study is only $1,000.

This study is important at the point of solving a major problem with simple materials and it will also contribute to the development of systems that can operate on all egg diameters instead of removable disks in future studies. Although there are a lot of researches on egg deterioration and egg-borne diseases in the literature, there is no shared study that gives a solution for the problem of broken egg. The development of a machine that is shared in this study will be able to obtain new models that can also count at the same time when cleaning the eggs in the future.

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