UPGRADE OF TRACTOR FORKLIFT FOR CHICKEN BOX TRANSPORT

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Abstract: *The research describes the development of a tractor-mounted forklift for transporting chicken crates in poultry facilities where conventional machinery cannot be used. The aim was to optimize chicken loading on upper floors, reduce physical strain, and improve working conditions. The practical part details the forklift's design, conceived as an upgrade to manual handling, and its testing under real conditions at the poultry farm. Results showed that the forklift reduced average transport time per crate by 11 seconds compared to a hand cart, a 15.7% improvement. Time savings were greatest over longer distances, while the hand cart was slightly faster at short ranges. The ability to move multiple crates simultaneously shortened truck loading by about 10 minutes, while reducing physical effort and increasing efficiency. The study demonstrates that cost-effective, in-house engineering solutions can significantly modernize poultry farming and improve working conditions, particularly in older facilities.*

Key words: *Poultry farming, broilers, crate transport, tractor forklift*

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1. Introduction

As in all other industries, poultry farming must achieve economies of scale to remain competitive. This requires sufficiently large production while simultaneously optimizing costs so that unit production expenses remain low enough to ensure profitability and business continuity. In broiler farming, the focus of this work, this means optimizing both internal and external animal transport, safeguarding animal welfare, and reducing the physical strain on workers, all while maintaining food security and supporting farm viability. Poultry farming plays a crucial role in modern agriculture by providing a significant share of affordable, high-quality protein for human nutrition. The success of broiler production depends not only on housing conditions and feed but also on the efficiency of work processes. Among the most critical tasks is chicken loading, which must be fast, well organized, minimally stressful for the animals, and as physically manageable as possible for workers (Mahor, 2025).

In the 1980s, Slovenian poultry farmers began constructing multi-story facilities (Figure 1) to maximize building space, without anticipating today's mechanization needs. As a result, entrances, ceiling heights, and load-bearing capacities of concrete floors are often limited, restricting access for larger transport equipment. This is particularly problematic on upper floors, where manual crate handling remains the primary method. Such practices slow down the loading process, require more labor, and increase physical strain on workers, which directly affects productivity and production costs.

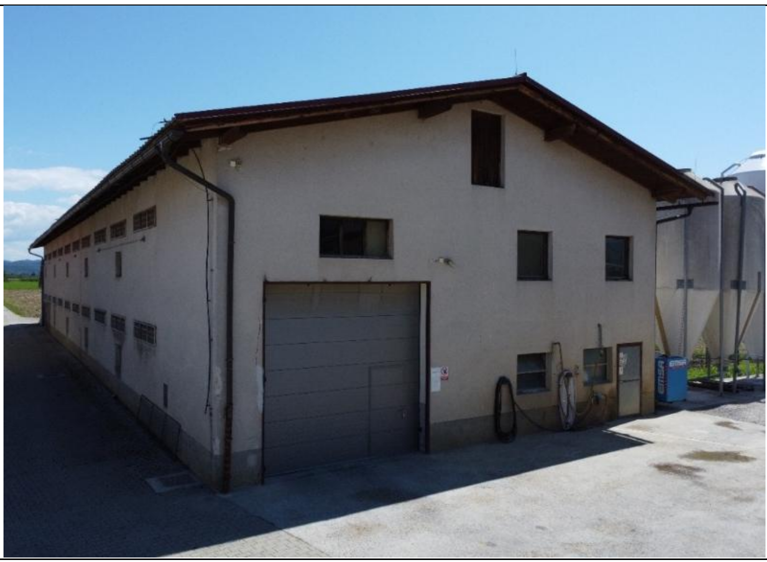

Fig. 1. Two-story chicken farm.

In this study, a tractor-mounted forklift was designed and constructed with the goal of facilitating faster and easier transport of chicken crates, thereby improving the cost and time efficiency of the loading process. The forklift's performance will be assessed by comparing conventional loading times with those achieved using the new device, with all measurements conducted on the upper floor of a poultry farm, where manual transport is still commonly employed due to structural limitations.

In addition to the experimental testing, the research examines relevant literature to identify the stress-related and other effects of loading on chickens.Particular attention is given to comparisons of manual and mechanical loading methods, evaluating their impact not only on operational efficiency but also on animal welfare. By combining practical testing with a literature-based analysis, the study seeks to provide a comprehensive understanding of how mechanization can contribute to optimizing loading processes, reducing physical strain on workers, and supporting more sustainable and efficient poultry production practices. The construction of the forklift and the research were done as part of the diploma thesis (Mahor, 2025).

The study was conducted on a single farm under specific structural and operational conditions, which may limit the generalizability of the findings. Furthermore, the assessment focused primarily on time efficiency and worker comfort, while other factors such as energy consumption, maintenance costs, and long-term durability were not evaluated. Future work will focus on optimizing the forklift's hydraulic and steering systems, integrating safety sensors for automated operation, and testing the system in various farm configurations to validate its wider applicability and long-term performance.

1.1 Raising chickens for meat

In recent decades, poultry farming has expanded significantly worldwide, as it provides a consistent supply of high-protein food essential for maintaining a healthy human population. However, the rapid growth of the poultry industry also carries negative consequences, including impacts on animal health—reflected in both meat quality and human health - as well as effects on the environment, soil fertility, and other areas (Gržinć et al., 2022; Vindiš et. al., 2016).

The modern and most common method of chicken farming in Slovenia (as well as in most developed countries) is intensive production in the form of floor-based housing with litter. This system is characterized by placing the entire flock at the same time, with all chickens being of the same age, which simplifies depopulation, vaccination, and the provision of other necessary conditions (Holcman et al., 1991). For broiler meat production to remain cost-effective, several factors influencing broiler growth must be ensured: the health of day - old chicks, properly prepared housing with optimal ventilation, temperature, and lighting, access to water and quality feed, stocking density, and a vaccination program (Perutnina Ptuj, 2017). In Slovenia, the most widespread practice is contract broiler production within intensive farming systems, where contractors are responsible for the housing facilities and equipment, bird care, litter, water supply, and heating, while the poultry company provides day-old chicks, feed, veterinary care, and processing (Holcman et al., 2020; Stajnko et. al., 2024).

1.2 Chicken loading process

The loading of chickens can be carried out in several different ways. Increasing awareness highlights the importance of proper animal handling to ensure both animal welfare and meat quality, while also implementing a cost - effective process that minimizes physical strain on workers (Wolff et al., 2019).

Preparations for chicken loading begin during the entire rearing period, with control weighing of at least 1% of the flock at specific ages to determine the slaughter date and prevent excessive or insufficient final body weight. To minimize injuries during loading, a light program is applied: in the last three days prior to loading, darkness is limited to a maximum of one hour per day, while during loading the facility remains dark, keeping chicken’s calmer; for this reason, loading is usually scheduled at night or early in the morning. Feed is restricted beforehand to empty the digestive tract and reduce faecal contamination during transport and processing, while water is available until just before loading. In facilities where manual catching is practiced, handlers must be properly trained and equipped to avoid injuring the animals and exposing them to unnecessary stress, and all unnecessary equipment must be removed in advance to ensure safety. Since catching is performed in near darkness, blue lighting is used, under which poultry remain calm. Transport to the slaughterhouse takes place in designated containers on specialized vehicles, which must be cleaned and disinfected after each use to prevent the spread of disease. To avoid overheating and reduce stress, the number of animals per container is legally regulated according to live weight per square centimetre, with detailed recommendations provided in Annex D of the Perutnina Ptuj handbook (Perutnina Ptuj, 2017).

Chicken loading is a critical stage in poultry production and can be performed manually or mechanically (Figure 2) (Louton et al., 2019; Rakun et. al, 20215). Manual leg - catching, still common worldwide, inverts the birds and increases the risk of injuries and stress, while improper handling can lead to dislocations (Wolff et al., 2019). Safer manual methods, such as using plastic crates or the "abdomen technique," allow birds to remain upright, reducing wing flapping, stress, and physical strain on workers (Perutnina Ptuj, 2017; Wolff et al., 2019). Preparations for loading, including feed restriction, light programs, and careful handling, begin during the rearing period to ensure optimal bird welfare and meat quality. Containers are positioned close to the barn to minimize handling time, and specialized transport vehicles are cleaned and disinfected to prevent disease spread, with stocking densities regulated according to live weight (Perutnina Ptuj, 2017).

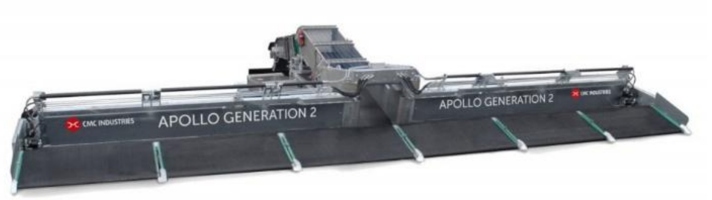

Fig. 2. CMC Apollo Generation 2 broiler loading combine.

A study conducted on 17 broiler farms in Germany compared manual loading with the use of the CMC Apollo Generation 2 harvester (Figure 2), focusing on behaviours indicative of fear as a proxy for stress (Wolff et al., 2019). Observations included wing flapping, attempts to escape, incidence of injuries and hematomas, and plasma cortisol levels.Results indicated that comparing manual and mechanical methods is challenging, as some behaviours, like wing flapping, are difficult to observe during mechanical loading.

Manual handling where chickens are held by both legs or wings reduces escape and stress, while carrying single birds increases wing flapping and injury risk. The wing-holding technique is preferred for welfare, keeping birds upright and minimizing cortisol release. Heavier birds are more prone to injury during manual loading, whereas mechanical methods are unaffected by weight, making them preferable for fast loading or heavier flocks. Environmental factors such as external light and temperatures above 20 °C increase stress during manual handling, further supporting mechanical loading when feasible. Limitations of mechanical methods include barn design and space requirements. Ultimately, the choice of loading method depends on farm conditions, equipment accessibility, flock characteristics, and the experience of the staff, with the goal of optimizing animal welfare (Wolff et al., 2019).

2. Methods and materials

2.1 Poultry farm

The tractor-mounted forklift we developed was designed for use on the poultry farm shown in Figure 1. The farm, built in 1981, consists of two levels with a total rearing area of approximately 1,000 m², an anteroom divided into clean and dirty areas, a control room, and storage space for equipment and medications. The rearing period lasts between 30 and 43 days, during which 18,000 to 20,000 chickens are raised. Approximately one-third of the flock is loaded around 30 days of age, depending on market demand and industry requirements, which also helps to adjust stocking density in accordance with regulations. The farm restocks the houses 5 to 6 times per year, resulting in over 100,000 chickens raised annually. The farm uses a manual loading method using 25 L plastic bins. To minimize contact between catchers and chickens, transport crates are brought as close as possible to the loading area. On the lower level, a forklift delivered by company is used to transfer crates between the truck and the barn. Since the forklift cannot access the upper level, crates are lifted to the upper floor doorway and placed on a cart for manual transport (Figure 3). Using a cart, a team of at least three people pushes empty crates into the barn to the loading area and then returns them filled with chickens to the exit. This task is physically demanding, as empty crates weigh 217 kg and full crates around 600 kg.

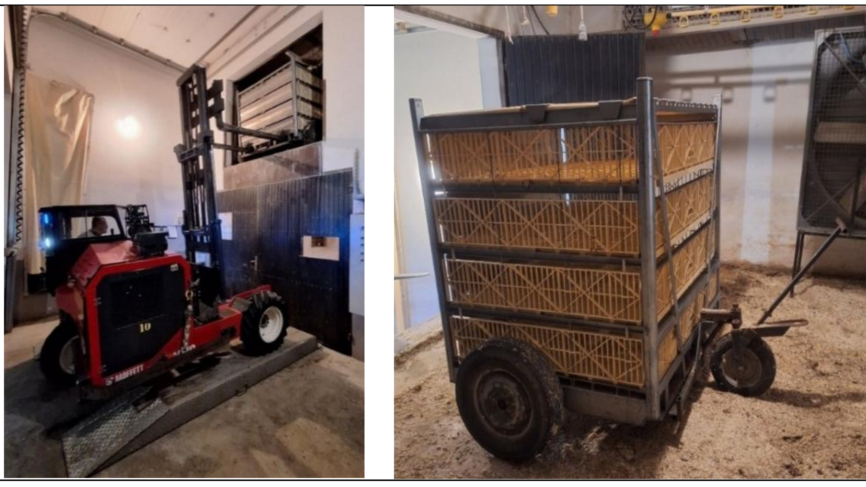

Fig. 3. The process of manually loading chickens.

2.2 Tractor forklift design

We developed the tractor forklift because access to the upper floor is not possible with heavier machinery. The design was inspired by the forklifts used by the chicken buyer to load the same crates into trucks for transport to the slaughterhouse. The tractor forklift had to be adapted to the load-bearing capacity of the concrete floor as well as to the height and width of the upper level.

Before starting the construction, we measured the chicken crates and the entrance dimensions to the upper floor, which are 2055 mm in height and 2385 mm in width. We also measured the interior of the facility, which is 12 meters wide and 40 meters long. Supporting columns run along the center of the building, further restricting the available space and limiting the maximum allowable machine width to 3700 mm.

2.3 The process of manufacturing a customized tractor forklift

The tractor forklift was built using the lifting mechanism and forks taken from a used manual high - lift forklift, which we modified to suit the needs of the tractor - mounted version. A three-point hitch, made of flat steel and dimensioned for a Category 1 tractor attachment (Figure 4, left), was welded onto the lifting mechanism. On both sides of the lifting mechanism, we welded L-shaped square tubes made from thick-walled steel, each fitted with swivel support wheels at the ends. The forks from the used forklift were too short and narrow for transporting the crates, so we extended them from 1000 mm to 1200 mm and reattached them to the fork carriage with a spacing of 645 mm (Figure 4, right). To lift the forks, we used an existing load chain from a hand forklift, through which we lift them with a 60/30-350 hydraulic cylinder.

We selected support wheels with a width of 110 mm and a diameter of 406 mm to ensure the machine could move over the soft bedding while remaining sufficiently manoeuvrable. It was also necessary to account for load capacity, as the wheels must support both the weight of the forklift (310 kg) and a fully loaded chicken crate (approximately 600 kg).

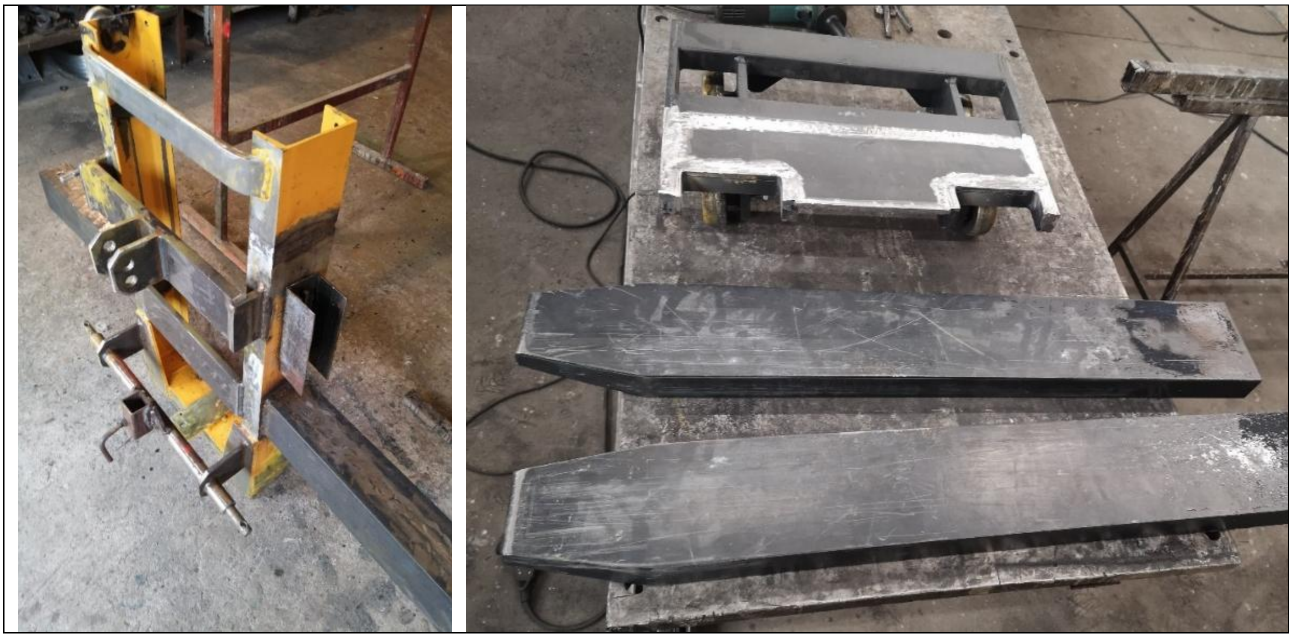

Fig. 4. Category one of three-point hitch (left) and fork modification (right).

2.4 Functional testing and adaptation of the forklift to field conditions

To simulate the loading process, we conducted the first test of the forklift using a 1000 L IBC tank filled with 600 L of water. The tractor forklift was attached to a Shibaura Garden tractor, which is also used for other tasks on the poultry farm. The tank was successfully lifted; however, driving was unsuccessful because the wheel spacing was too narrow, causing the wheels to hit the tank when turning. To solve this issue, we had to increase the wheel spacing to a total width of 2370 mm, which meant the forklift could no longer pass through the entrance to the upper floor. As a solution, we decided to implement a telescopic system for folding the wheel supports.

To enable passage through the door to the upper floor, we used telescopic beams that can be folded (shrunk) to a width of 1670 mm. During operation, the beams are expanded to a total width of 2370 mm (Figure 5) and secured with bolts.

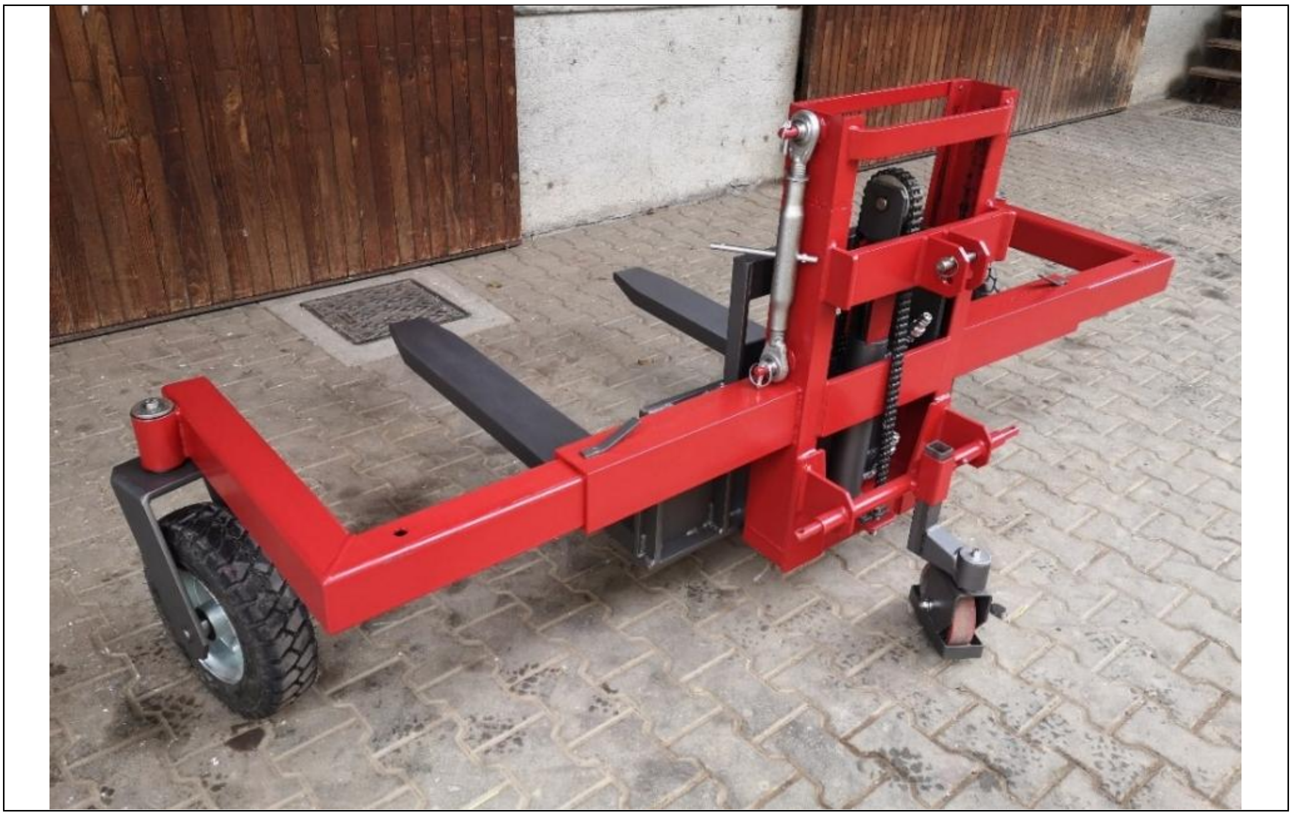

Fig. 5. Tractor forklift with extended telescopic arms.

After correcting the error, we repeated the test successfully and proceeded with a trial on the farm during chicken loading. In this test, we measured the time needed to transport an empty crate from the entrance to a set point inside the farm and a full crate back to the entrance.

To demonstrate the forklift's benefits compared to previous methods, total loading time could be used, but this approach is unreliable due to many uncontrolled variables such as external transport speed, manual catching efficiency, chicken weight and behaviour, or bedding conditions. Instead, we focused on measuring transport time within the farm over defined distances, reducing misleading variables and ensuring more accurate results.

3. Results

Figure 6 shows the constructed tractor forklift together with the tractor, which is used to transport crates with chickens. To ensure safety when loading in the dark, reflectors and lights were installed on the external parts of the forklift.

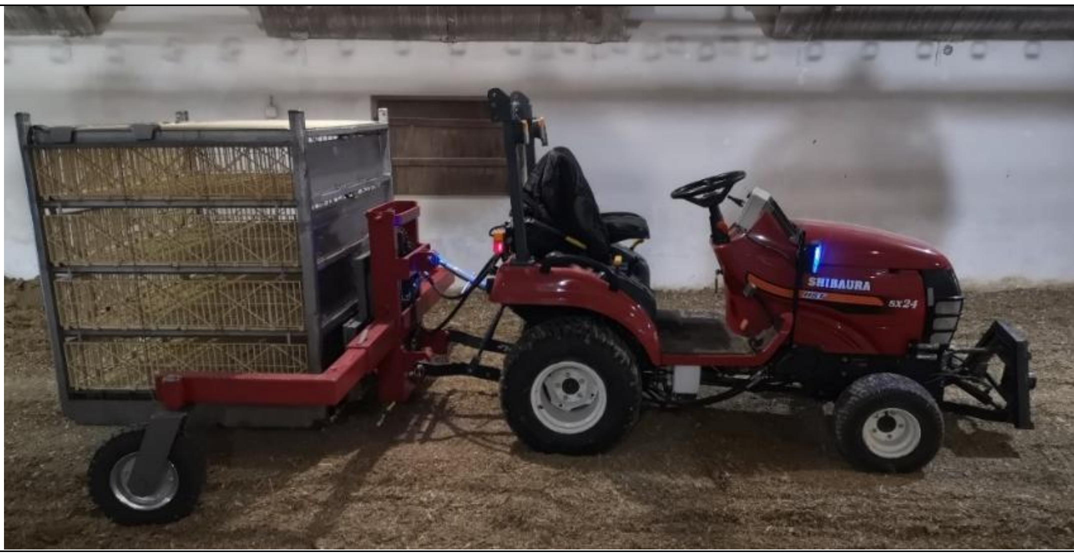

Fig. 6. Tractor forklift.

3.1 Performing time measurements when working with a tractor forklift

We compared the efficiency of the forklift with the loading time without it (Table 1). As reference points inside the barn, we used the support columns placed every 5 meters along the center, nine in total. We anticipated that the advantages of the tractor forklift (speed, functionality, etc.) would become more evident at greater distances, since turning the forklift is naturally slower than manoeuvring a handcart.

	A STROLLER (min)	**FORKLIFT (min)**	**DIFFERENCE TROLLEY FORKLIFT (min)**	**INDEX (%)**
2. pillar	0:22	0:42	-0:20	90,9
3. pillar	0:40	0:50	-0:10	25,0
4. pillar	0:57	0:55	0:02	-3,5
5. pillar	1:10	1:01	0:09	-12,8
6. pillar	1:21	1:01	0:20	-24,6
7. pillar	1:30	1:08	0:22	-24,4
8. pillar	1:39	1:07	0:32	-32,3
9. pillar	1:47	1:13	0:34	-31,7
Average driving time	1:10	0:59	0:11	-15,7

Tab. 1. Forklift driving time measurement.

To reduce human influence, we measured times when the forklift was first built and again a year later, once the operator had gained experience. Within that year, the average time improved by 17 seconds at all measurement points compared to the initial trial. Table 1 presents the results for loading with a handcart (the previous method) and with the forklift after one year of use. The forklift proved advantageous at nearly all points, except at the 2nd and 3rd columns, where the handcart was faster due to easier manoeuvring. The difference ranged from 20 seconds in favour of the handcart at the first point to 34 seconds in favour of the forklift at the last point. On average, the time improved by 11 seconds, corresponding to a 15.7% reduction in transport time from the entrance to the loading site.

One of the key advantages of using the forklift is that it allows us to bring four crates to the chickens at once. This increases team productivity, as workers no longer have to wait for an empty crate, which often happened when using handcarts with a maximum of two crates. The total loading time for one truck (20 crates) was also reduced by an average of 10 minutes, since the same number of workers can now load more crates simultaneously. Movement inside the barn has become easier and faster, from catching the chickens to placing them into the crates, which further boosts efficiency. In addition, the absence of a cart beneath the crate makes the physical loading process easier, as full crates no longer need to be lifted as high. Workers noted that loading the top compartments is particularly easier, since they are now positioned 15 cm lower. As a result, we can assume that reduced physical strain also benefits animal welfare, as studies (Wolff et al., 2019) show that more strenuous handling of chickens leads to higher injury rates.

The tractor forklift also eliminates the need for at least three people previously required to push and transport the crates, thereby reducing labor costs. Since the tractor forklift replaces the handcart, external forklifts can now unload crates directly onto the floor of the upper level, eliminating the need for ramps. This makes external transport less demanding and safer. We can also assume that crate transport to the upper floor is faster, although this was not directly tested in this part of the study.

4. Conclusion

This study addressed the problem of inefficient and physically demanding transport of chicken crates in facilities where standard machinery cannot operate. To solve this, a tractor-mounted forklift was designed and tested, providing an accessible and adaptable solution for confined poultry farm environments. The developed system effectively reduced the physical workload of employees and significantly improved transport efficiency. Measurements confirmed that crate transport time was shortened by an average of 11 seconds (15.7%), validating the hypothesis that the new solution would achieve at least a 10% improvement over the manual handcart method.

The project successfully demonstrated that targeted, in-house engineering can resolve specific on-farm challenges with minimal resources and high practical value. The tractor-mounted forklift not only enhances operational efficiency but also improves the working conditions of farm staff.

In the future, further optimization will focus on increasing lifting precision, enhancing safety features, and exploring automation options to make the system even more effective and sustainable for broader agricultural use.

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