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THE IMPACT OF REDUCED LOADING DENSITY ON SLAUGHTER CHICKEN TRANSPORT: A HUNGARIAN CASE STUDY

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Abstract: *The European Food Safety Authority (EFSA) has issued a new recommendation regarding the regulation of animal transport, which includes providing more space for animals during transportation. Complying with this recommendation has various economic, environmental, and animal welfare implications. A case study was conducted in cooperation with two slaughterhouses in Hungary to assess the animal welfare, economic, and environmental consequences of reducing bird density during broiler transport. For both companies, data from two consecutive transport trips were analysed: one trip followed the current regulation and practice regarding stocking density, while the other used the lower density recommended by EFSA. Although the two companies used different types of crates and loading methods, the mode of transport, weather conditions, personnel involved in loading and unloading, and measurement procedures were the same. Worse animal welfare indicators (e.g., dead-on-arrival birds, confiscations, limb injuries, bruises) were observed in both cases when loading density was reduced in line with EFSA's recommendation. Therefore, no clear benefits from an animal welfare perspective could be identified. From an economic standpoint, the implementation of this recommendation would require significant investment, result in higher per-unit transportation costs, and ultimately lead to an increase in poultry meat prices. Furthermore, the environmental impact would also be negative: more transport trips would be needed, leading to increased greenhouse gas emissions and greater water usage for washing vehicles and containers.*

Keywords: *transport; broiler chicken; animal welfare; economics; environmental impacts*
(JEL code: D24, M11, Q10)

INTRODUCTION

The rapid growth of the global population, coupled with the rising demand for animal-based protein sources, has placed increasing pressure on livestock production systems to satisfy these nutritional needs. Concurrently, animal welfare has emerged as a critical area of concern, attracting growing attention from both the scientific community and the general public. This heightened interest is particularly evident within the European Union and numerous other countries, where societal expectations, regulatory frameworks, and sustainability objectives are increasingly aligned with the promotion of animal welfare (Koknaroglu and Akunal, 2013).

In contemporary discourse, animal welfare is recognized not only as an ethical imperative but also as a factor with significant legal, economic, and trade-related implications. It has become an essential consideration in policy-making, international agreements, and the development of sustainable agricultural practices (Algers, 2011; Koknaroglu and Akunal, 2013). Animal welfare is a complex and multifaceted issue that encompasses scientific, ethical, economic, and political dimensions. Consequently, research in this field requires an interdisciplinary approach that integrates the expertise of specialists from various domains. Biologists, ethologists, veterinarians, economists, legal experts, and policymakers all play a vital role in deepening our understanding and developing effective strategies. Improving animal welfare is not only a moral responsibility but also brings significant societal and economic benefits in the long run (Carenzi and Verga, 2009).

While simplistic definitions may equate animal welfare with the animal's immediate state of comfort or distress (Hemsworth et al., 2014), modern conceptualizations are considerably more comprehensive. Current scientific understanding emphasizes the importance of providing animals with an environment that enables the expression of species-specific natural behaviours. Enhancing welfare standards in intensive production systems is not only a means of reducing suffering but also contributes to improved productivity, product quality, disease resistance, and consumer trust. Thus, animal welfare should be viewed not merely as a moral concern but as a foundational element of sustainable and socially responsible animal agriculture (Koknaroglu and Akunal, 2013).

Transportation represents a critical factor influencing animal welfare within livestock production systems and therefore warrants particular attention. During the process of animal transport, multiple stressors may interact simultaneously, each potentially compromising the welfare of the animals involved (Marahrens et al., 2011).

In May 2020, the European Commission announced in the "Farm to Fork" strategy (EC, 2020) that it would review animal welfare legislation by the end of 2023 to align it with the latest scientific findings. This included Council Regulation 2005/1/EC, which addresses the protection of animals during transport. Currently, Regulation 2005/1/EC defines the responsibilities of all actors involved in the transport chain of live animals entering or leaving the EU. This encompasses monitoring tools, inspections, and transport equipment. On 7 December 2023, the Commission adopted a new regulatory proposal for the Council and the European Parliament (EC, 2023a) concerning the protection of animals during transport, which would replace Regulation 2005/1/EC.

The main objectives of the proposal:

- Reducing animal welfare issues associated with long journeys and multiple loading and unloading operations;
- Providing animals with more transport space;
- Improving transport conditions for vulnerable animals;
- Preventing animals from being exposed to extreme temperatures;
- Facilitating compliance with EU animal welfare rules, including through digitalization;
- Enhancing the protection of animals exported outside the EU (EC, 2023b).

The legislative proposal is based on the opinions of the European Food Safety Authority (EFSA) (EFSA et al., 2022) and the Commission’s assessment of the proposed changes' impact on animal welfare, economics, the environment, and society. The legislative process is well advanced, with the deadline for submitting amendments set for the second quarter of 2025, and the European Commission’s vote expected in the fourth quarter of 2025.

One of the most significant proposed changes affecting slaughter chicken transport is that space requirements for animal species and transport equipment shall at least comply with the figures laid down in Chapter VII of the draft regulation.

Animals occupy space in three dimensions, but measuring their volume is challenging. Therefore, live weight is used as a proxy measurement, as it closely correlates with the space animals occupy. Based on this, the general allometric equation is applied to calculate the minimum floor area required during transport (EFSA et al., 2022):

$$\text{Space requirement (cm}^2\text{)} = 290 \times \text{live weight (kg)}^{2/3} \qquad (1)$$

Under the current regulations, birds up to 3 kg live weight require 160 cm² per kg in transport containers (Table 1). According to the EFSA recommendation, birds weighing 2.5 kg require 214 cm² per kg, while birds weighing 3 kg require 201 cm² per kg. This represents a 26-34% increase in space requirements, leading to a proportional reduction in live animal transport capacity per vehicle.

Table 1. Characteristics of the current and proposed regulations on stocking density for poultry transport in containers

Category: Other poultry (excluding day-old chicks), weight (kg/bird)	Minimum space requirement (cm²/kg)
Current regulation (Regulation 1/2005/EC), Annex I, Chapter VII, Section E: Poultry	
< 1.6	180 – 200
1.6 – 3	160
3 – 5	115
5 <	105
Marel's proposal for compliance with the current regulation	
1.6 – 3	170
EFSA recommendation, 2022	
1	290
1.5	253
2	230
2.5	214
3	201
3.5	191
4	183
4.5	176
5	170

Source: Regulation 2005/1/EC; EC, 2023a

The aim of the survey was to determine, based on practical experience, the animal welfare consequences of reducing bird density during slaughter chicken transport. We hypothesized – contrary to the intended objectives of animal welfare legislation – that the increased free space during transport would lead to a higher number and proportion of injuries, as well as a similar trend in the rate of dead-on-arrival birds. In addition to animal welfare issues, the study also aimed to explore the economic and environmental impacts.

MATERIALS AND METHODS

A case study was conducted with the involvement and cooperation of two slaughterhouses in Hungary. The study (loading and transport) took place at the end of January 2025. The transport distance was 72 km for the first company and 150 km for the second company. The study was conducted on heavyweight broilers (2.84 and 3.18 kg per bird), which came from the same barn for each company. For both companies, data from two consecutive transport trips were analysed. One trip ("Truck A") followed the current regulation and practice regarding animal density, while the other ("Truck B") was filled with the animal density according to the EFSA recommendation, which requires more space. The two companies used different types of crates, and as a result, the loading method also differed. Efforts were made to ensure that the internal conditions within each company were consistent for both transport trips ("A" and "B"). The loading and unloading of the birds were performed by the same crew. Both trucks followed the same route, at the same speed, and with similar driving styles. The consignments involved in the study were handled separately at the processing plant. The qualification was carried out according to the generally applied practice at each company and was performed by the same individuals.

The main data and characteristics of the 1st company's animal transport are summarized in Table 2. The crate type used by Company 1 was a traditional plastic poultry transport crate (85×66×33 cm). The average weight of the transported flock was 2.84 and 2.9 kg. According to the current regulation, 10 birds can be loaded in such a crate with this average weight. In contrast, according to the EFSA recommendation, only 7 birds can be placed in the crate, which is 30% fewer. The difference is clearly visible in Figures 1 and 2. Table 3 summarizes the key data and characteristics of poultry transport for Company 2. The container type used by the company was the Stork Marel Atlas container. The average weight of the transported flock was 3.18 kg. According to the current regulation, the upper crates of the applied containers can hold 52 chickens of this weight. In contrast, the EFSA recommendation allows for 23% fewer birds, meaning only 40 chickens can be placed in each upper crate. This difference is visually illustrated in Figures 3 and 4, showing the lower crates of the containers.

Table 2. Details of the animal transport – Company 1

Denomination	Truck "A" (according to the current regulations)	Truck "B" (according to the EFSA recommendation)
Distance of transport (km)	72 km	
Start (date, hours, min)	28/01/2025 21:30	28/01/2025 23:25
Arrive (date, hours, min)	28/01/2025 23:01	29/01/2025 0:55
Type of loading vehicle used	Manual loading and forklift	
Type of truck used	Trailer-based livestock transport vehicle	
Used container details	plastic poultry transport crate, 85×66×33 cm, useful floor area 76×57 cm (4,332 cm^2)	
Loading method, loading brigade	by hand, 16 person	
Loading time of truck (hours, min)	1 h 30 min	1 h 20 min
Average weight on farm (kg/bird)	2.84	2.90
Procedure and main features of processing plant qualification	Dedicated personnel (quality inspectors) examined the rate and type of limb injuries on the evisceration line. A full count was applied instead of sampling. The suspension method and line speed were the same for both transport truck.	
Number of birds per containers	10	7
Total number of chicken per truck	5,040	3,528
Total quantity at slaughterhouse (chicken live weight kg per truck)	14,300	10,240

Source: Own elaboration.

Figure 1. Plastic crate filled according to the current regulation (10 chickens per crate)

Source: Own elaboration

Figure 2. Plastic crate filled according to the EFSA recommendation (7 chickens per crate).

Source: Own elaboration

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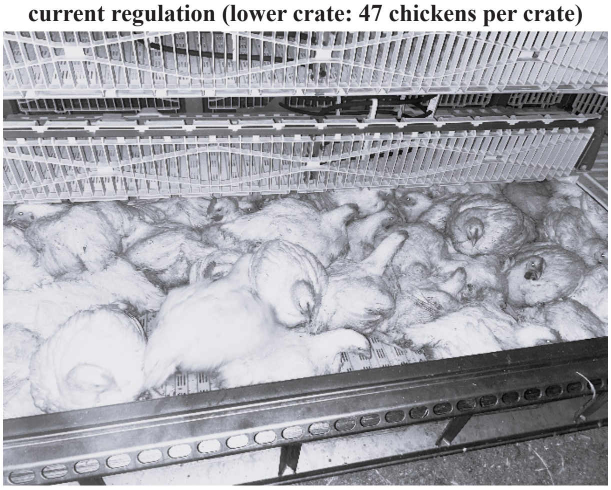
Table 3. Details of the animal transport – Company

Denomination	Truck "A" (according to the current regulations)	Truck "B" (according to the EFSA recommendation)
Distance of transport (km)	150 km	
Start (date, hours, min)	31/01/2025 4:35	31/01/2025 5:20
Arrive (date, hours, min)	31/01/2025 6:45	31/01/2025 7:35
Type of loading vehicle used	Manitou MLT 625-75 H	
Type of truck used	Volvo + Schwazmüller RH125	
Used container details	Stork Marell Atlas container: 5-tier containers, lower crate: 233×100 cm (23,300 cm^2), 4 additional crates: 233×110 cm (25,630 cm^2) each, crate height: 28.3 cm. Each crate is separated in the middle.	
Loading method, loading brigade	5 persons (2-person packing teams) Both trucks were loaded using the one-leg catching technique.	
Loading time of truck (hours, min)	45 min	45 min
Average weight on farm (kg/bird)	3.18	3.18
Procedure and main features of processing plant qualification	Examining the carcasses on the line for one minute. The line operated at a speed of 16,650 birds per hour, which corresponds to an average of 277 birds per minute.	
Number of birds per containers	47/52 47 birds in the lower crates 52 birds in the other crates.	37/40 37 birds in the lower crates 40 birds in the other crates.
Total number of chicken per truck	5,610	4,334
Total quantity at slaughterhouse (chicken live weight kg per truck)	17,840	13,782

Source: Own elaboration.

Figure 3. Stork Marel Atlas container filled according to the current regulation (lower crate: 47 chickens per crate)



Source: Own elaboration

Figure 4. Stork Marel Atlas container filled according to the EFSA recommendation (lower crate: 37 chickens per crate)

Source: Own elaboration

At the two companies, not only were there differences in the available space and loading quantity for the crates used, but also a significant variation in the loading time. Despite the fact that the transport vehicle capacity of Company 2 was 11% and 22% higher than that of Company 1, the loading time was half as long for Company 2, which used the larger crate type.

It is well-known that the handling and loading of animals into transport crates, as well as the transportation itself, can cause stress for the animals. The number of animals that die during transport (dead-on-arrival birds) serves as a direct indicator of pre-slaughter welfare issues (Gickel et al., 2024). During the study, in addition to the amount of dead-on-arrival birds at the processing plant, further data related to objective animal welfare conditions linked to transportation were collected, such as confiscation, the number of birds with limb injuries, and the number of birds with bruised body parts. From these quantitative data, we calculated ratios relative to the number of birds transported per truck.

RESULTS AND DISCUSSION

The results of the study are presented separately for each company due to the different types of crates used. For Company 1 (Table 4), the number of birds that can be transported per truck decreased by 30%, from 5,040 to 3,528 birds. The rate of dead-on-arrival birds increased from 0.16% to 0.31%, while the confiscation rate increased from 0.95% to 1.47%. The number of limb injuries rose by 1.64 percentage points, and the number of birds with bruised body parts increased by 0.61 percentage points. In the case of Company 2 (Table 5), the number of birds that can be transported per truck decreased by 22.7%, from 5,610 to 4,334 chickens. The rate of died-on-arrival increased from 0.12% to 0.32%, while the confiscation rate increased from 0.45% to 1.5%. The number of limb injuries increased by 0.14 percentage points, and the number of birds with bruised body parts increased by 0.28 percentage points.

When comparing the data from both companies, a significant difference is observed in the proportion of birds with limb injuries and birds with bruised body parts in both transport cases. This difference is likely related to the varying crate types, loading crews, and processing plant qualifications, which suggests the need for further investigation.

By averaging the data of the two slaughterhouses, it can be concluded that, depending on the type of crate and the average weight of transported birds, the capacity of the transport vehicle and the number of birds that can be transported is reduced by 22-30%. The dead-on-arrival bird and confiscation rate has roughly doubled at the loading density recommended by EFSA.

Animal welfare considerations

Although our results cannot be considered statistically representative, they clearly highlight that the EFSA recommendation regarding increased space for poultry during transport do not have a positive impact on the development of the most important animal welfare indicators. The Poultry Veterinary Study Group Europe (PVSGE), in its comments on the Commission's draft regulation (PVSGE, 2024), draws attention to two recent studies on the transportation of large numbers of broiler chickens in the United Kingdom (Allen et al., 2023)

Table 4. Changes in objective animal welfare indicators related to broiler transport –Company 1 (plastic poultry transport crate)

Denomination	Truck "A" (according to the current regulations)		Truck "B" (according to the EFSA recommendation)		Difference ("B" – "A")		Difference (Ratio ("B" – "A") / Ratio "A") (%)
	Value	Ratio* (%)	Value	Ratio* (%)	Value	Ratio* (%)	
Dead-on-arrival birds (pcs/truck)	8	0.16	11	0.31	3	0.15	96
Dead-on-arrival birds (kg/truck)	22.7	0.16	31.9	0.31	9.2	0.15	96
Confiscated birds (pcs/truck)	48	0.95	52	1.47	4	0.52	55
Confiscated birds (kg/truck)	117.2	0.82	129.7	1.27	12.5	0.45	55
Number of birds with limb injuries (pcs/truck)	179	3.55	183	5.19	4	1.64	46
from this							
freshly bruised wing (pcs)	32	0.63	39	1.11	7	0.47	74
freshly bruised thigh (pcs)	9	0.18	14	0.40	5	0.22	122
previously bruised wing (pcs)	5	0.10	5	0.14	0	0.04	43
previously bruised thigh (pcs)	5	0.10	4	0.11	-1	0.01	14
fracture of the wing (pcs)	31	0.62	36	1.02	5	0.41	66
fracture of the thigh (pcs)	8	0.16	12	0.34	4	0.18	114
open fracture of the wing (pcs)	80	1.59	91	2.58	11	0.99	63
open fracture of the thigh (pcs)	2	0.04	3	0.09	1	0.05	114
Number of birds with bruised body parts (pcs/truck)	68	1.35	69	1.96	1	0.61	45

*Ratio to the number of birds transported per truck (%)

Source: Own elaboration.

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Table 5. Changes in objective animal welfare indicators related to broiler transport –Company 2 (Stork Marell Atlas container)

Denomination	Truck "A" (according to the current regulations)		Truck "B" (according to the EFSA recommendation)		Difference ("B" – "A")		Difference (Ratio ("B" – "A") / Ratio "A") (%)
	Value	Ratio* (%)	Value	Ratio* (%)	Value	Ratio* (%)	
Dead-on-arrival birds (pcs/truck)	7	0.12	14	0.32	7	0.20	159
Dead-on-arrival birds (kg/truck)	22.3	0.13	44.5	0.32	22.2	0.20	158
Confiscated birds (pcs/truck)	25	0.45	65	1.50	40	1.05	237
Confiscated birds (kg/truck)	79.5	0.45	206.7	1.50	127.2	1.05	237
Number of birds with limb injuries (pcs/truck)	14	0.25	17	0.39	3	0.14	57
from this wing injury (pcs)	11	0.20	15	0.35	4	0.15	77
thigh injury (pcs)	3	0.05	2	0.05	-1	-0.01	-14
Number of birds with bruised body parts (pcs/truck)	18	0.32	26	0.60	8	0.28	87

*Ratio to the number of birds transported per truck (%)

Source: Own elaboration.

and Germany (Gickel et al., 2024). These studies reveal that the stocking density during transport had no significant effect on the rate of dead-on-arrival birds. These studies also emphasize that the dead-on-arrival rate is one of the most important welfare indicators for animal transport. We agree with the PVSGE's view that reducing stocking density does not lead to significant improvements in key welfare indicators. On the contrary, we anticipate an increase in injuries during transport due to slipping, wing flapping, and excessive trampling if the birds' space in the transport crates is increased. These factors negatively affect the birds' welfare and also increase the proportion of confiscated and injured birds in the processing plant, ultimately leading to a decrease in the quantity of products leaving the processing plant.

In warmer conditions, the transporter may choose to reduce the number of birds placed in the transport crates, but in our opinion, it should not be mandated that the space per bird must be increased on every transport. This is supported by the results of a Canadian study (Caffrey et al., 2017), which showed that higher stocking densities were beneficial during exposure to cold weather, as in colder conditions, a statistically significant higher rate of dead-on-arrival birds was observed with lower stocking densities.

A previous Hungarian survey (Kopecsnik, 2008) found that the evaluation of increasing space per bird was not conclusive. In this survey, with a stocking density of less than 207 cm²/kg, the rate of dead-on-arrival birds was 0.6%, while for densities above this, it was 0.49%. However, the author highlights that injuries during transport occurred more frequently with greater space per bird (0.31% for less than 207 cm²/kg; 0.51% for more than 207 cm²/kg), presumably due to impacts and skidding during braking and turning. With more space, the animals have more opportunity for wing flapping and shifting, which also increases the likelihood of liver ruptures, wing and leg fractures, and bruising. Similar findings were observed in a Portuguese slaughterhouse survey (Saraiva et al., 2020), which examined 64 short-distance transports of broiler chickens with an average weight of 1.85 kg. The study found a correlation between increased space during transport and the frequency of bruising: the likelihood of bruising exceeding 4% increased linearly, from about 20% (for 180 cm²/kg space) to 60% (for 230 cm²/kg space). Based on this, the study suggested that transport containers providing less space per individual could be more effective in preventing bruising, as the birds support each other's bodies, reducing the risk of falling, and minimizing the need for spreading wings and legs to maintain balance.

Economic consequences

In addition to the welfare considerations mentioned, the planned increase in space requirements has significant economic impacts. A direct loss is represented by the increasing rate of dead-on-arrival birds and confiscation.

Assuming a farm-gate cost of 425 HUF/kg (with an exchange rate of 410 HUF/EUR, equivalent to 1.04 EUR/kg), the value of live animals per transport load, calculated per 100

Table 6. Changes in the specific value of processable chickens calculated at the farm-gate and the specific transport costs

Denomination	Company 1		Company 2	
	Truck "A" (according to the current regulations)	Truck "B" (according to the EFSA recommendation)	Truck "A" (according to the current regulations)	Truck "B" (according to the EFSA recommendation)
Total quantity at slaughterhouse (chicken kg/truck)	14,300	10,240	17,840	13,782
Value of chickens calculated at the farm-gate (EUR/truck)	14,823	10,615	18,493	14,286
Processable quantity after deduction of mortality and condemnation (chicken kg/truck)	14,160	10,078	17,738	13,531
Farm-gate value per kilogram of processable chicken (EUR/100kg)	104.68	105.32	104.25	105.58
Transport cost (EUR/truck)	293	293	611	611
Transport cost per kilogram of processable chicken (EUR/100kg)	2.07	2.91	3.44	4.52

Source: Own elaboration.

kilograms of processable live weight, which appears as a specific raw material cost in the processing plant, increased by 0.64 and 1.33 EUR (0.6% and 1.28%, respectively) based on the examined sample (Table 6). This could translate into an additional cost of 5.1 million EUR on an industry-wide level, considering the domestic broiler purchasing volume in 2024 (521,000 tons).

A lower bird density allows for the transport of fewer birds, which increases the transport costs per unit of live weight. The transport cost depends on the type of transport vehicle and the distance travelled. Assuming a transportation cost of 2.04 EUR per kilometre, the cost per 100 kilogram of processed chicken increased by 0.84 EUR and 1.07 EUR (40.5% and 31.1%, respectively) for both companies. This also results in a significant additional cost at the industry level, but we will not quantify it here since the distances of the transports in our study are not considered average at the national level.

Due to the lower loading density, not only do the transport costs per unit of live weight increase, but the capacity of the transport vehicles needs to be increased by 30-40%, which comes with significant investment requirements. In addition, the amount of water and chemicals (detergents, disinfectants) used to wash the transport vehicles and containers between transports, as well as the associated costs, increases proportionally.

Beyond the economic implications discussed, it is also important to address the impacts on the efficiency of the slaughter line. In a well-organized, highly automated facility, the speed of the slaughter line and the hanging of birds on hooks from the transport crates are optimized in terms of logistics and labor force organization. Under normal conditions, the second slaughterhouse (Company 2) operates with a capacity of 16,600 birds per hour, requiring at least 50 birds per crate. When processing the birds from the "B" truck (loaded according to the EFSA recommendation), it was observed that every 5th hook remained empty, and the slaughter line operated at a capacity of 13,002 birds per hour. This resulted in a 21.7% decrease in efficiency, which, due to relatively high fixed costs (depreciation of expensive machinery and equipment, a significant portion of labour costs, energy costs, etc.), clearly increases the cost of chicken meat leaving the facility. According to expert estimates, the cost response coefficient of processing plant costs, including raw material costs, is around 0.8. With such a cost structure (20% fixed and 80% variable costs), a 21.7% reduction in capacity would lead to an approximately 5% increase in chicken meat production costs.

Environmental consequences

The 30-40% increase in the number of trips is reflected not only in fuel consumption but also in greenhouse gas emissions and the ecological footprint of the activity to the same extent. The amount of water used for washing vehicles and containers also increases proportionally. In the case of Company 2, we were able to gather information on the carbon dioxide emissions of the transport vehicles, which is 814 grams per kilometre. With the current regulation's loading, the carbon dioxide emissions per kilogram of live weight delivered was 0.014 kilograms for the 150-kilometer round trip. Due to the lower loading density, the carbon dioxide emissions per kilogram of live weight increased to 0.018 kilograms (a 22.2% rise).

CONCLUSION

One of the main measures of the European Green Deal is the "Farm to Fork" strategy, which aims to move the current EU food system towards a more sustainable model. We believe that the measures introduced under this strategy, particularly regarding animal welfare in the context of this article, should contribute to all three fundamental pillars of sustainability (environmental, social, and economic), or at least positively affect one pillar without negatively impacting the other two. The results of the case study presented highlight that the European Commission's new draft regulation negatively impacts the sector's stakeholders from both an economic and environmental perspective, and there is no evidence to suggest that there would be any benefits from an animal welfare standpoint.

Worse animal welfare indicators (e.g., dead-on-arrival birds, confiscations, limb injuries, bruises) were observed when loading density was reduced in line with EFSA's recommendation. Based on these results our hypothesis is accepted: Contrary to the intended objectives of animal welfare legislation the increased free space during transport would lead to a higher number and proportion of injuries, as well as a similar trend in the rate of dead-on-arrival birds. From an economic standpoint, the implementation of this recommendation would require significant investment, result in higher per-unit transportation costs, and ultimately lead to an increase in poultry meat prices. Furthermore, the environmental impact would also be negative: more transport trips would be needed, leading to increased greenhouse gas emissions and greater water usage for washing vehicles and containers.

Our study was exploratory and cannot be considered statistically representative. Therefore, similar studies are recommended to conduct not only at the Hungarian level but also internationally. We also suggest repeating the study in Hungary under warmer weather conditions and over varying transport distances. Unfortunately, during the test, we were unable to measure the weight loss (at the farm and slaughterhouse scales), which could indirectly indicate increased movement of the transported birds associated with more space (e.g., wing flapping). More movement may be associated with greater stress on the animals, which should be avoided from an animal welfare perspective.

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