The Impact of Early Thermal Manipulation on The Hepatic Energy Metabolism of Mule Duck

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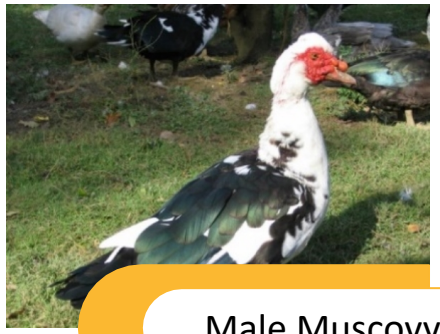
The *foie gras* production

Mule duck : the main species for the foie gras production

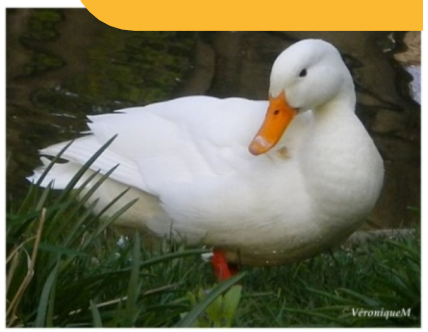


Male Muscovy duck

Good for

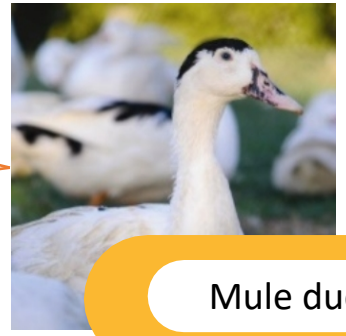
Foie gras production

Female Pekin duck



Good for

Muscle production



Mule ducks (males)

Heterosis effect

Muscle and *foie gras* production

99 % of the French *foie gras* production

(Davail et al., 2003; Baéza et al., 2005)

The *foie gras* production

Incubation step : first step of rearing

Incubation

Eggs were incubated during 30 days (**4 weeks**)

Control conditions

Temperature	37.6 °C
Relative humidity	60 to 65 %
Egg rotation	90° every 3h
gas exchanges	ventilation on

Incubator at the experimental station

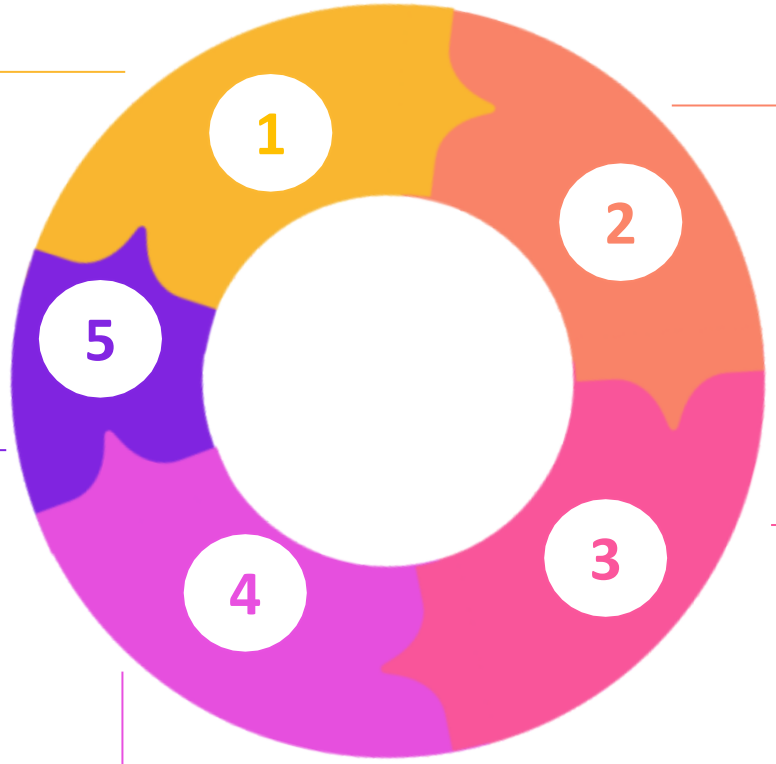
(Barott, 1937; Landaeur, 1961; El-Hanoun et al., 2012; Abd El-Hack et al., 2019)

The *foie gras* production

Segmentation of the rearing period of mule duck

Incubation

Eggs were incubated during 30 days (**4 weeks**)



Beginning of rearing

Rearing in a closed buidling with a starter diet during **4 weeks**

Force-feeding

Mix of corn flour, water and vitamins distributed **twice a day** and during almost **2 weeks** (12 days)

Rearing

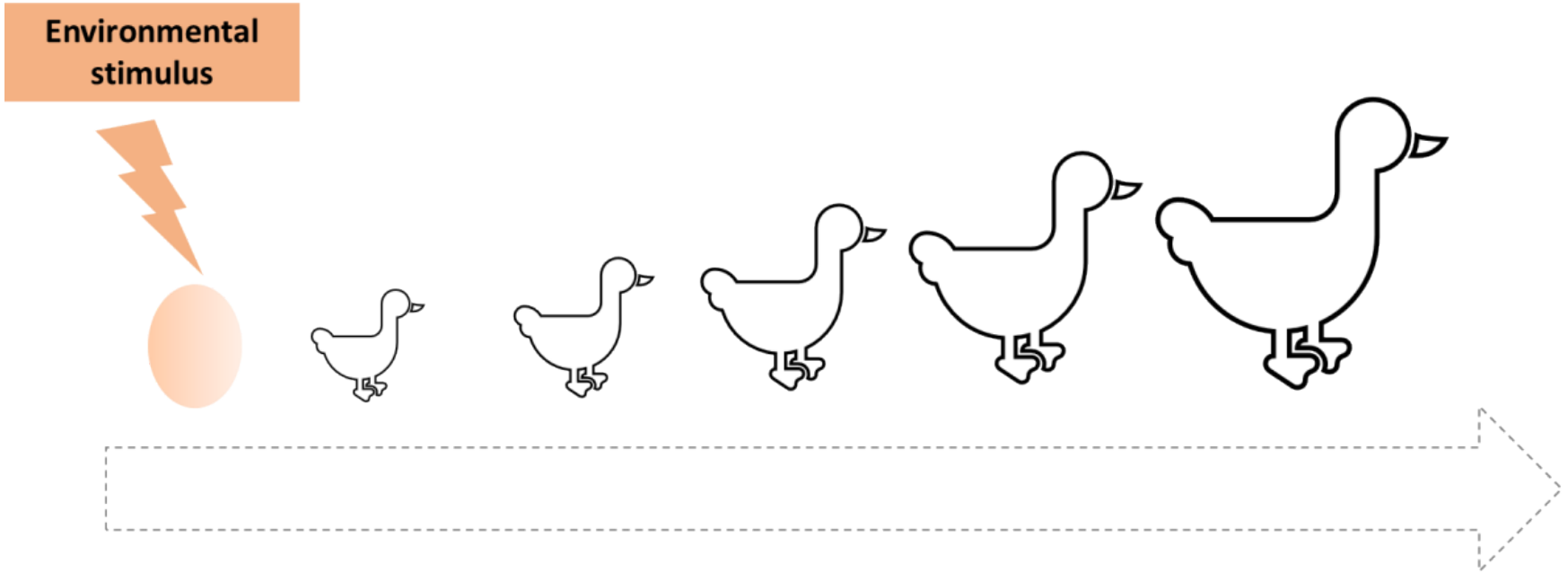
Growing diet and outside access during **4 weeks**

Force-feeding preparation

Hourly rationed (**1h/day** of feeder opening) with the growing diet and outside access during **4 weeks**

Early thermal programming

Programming: impact of early environmental stimulus on the futur phenotype



What are the consequences of a thermal manipulation at different stages in a duck's life ?

Environmental stimulus

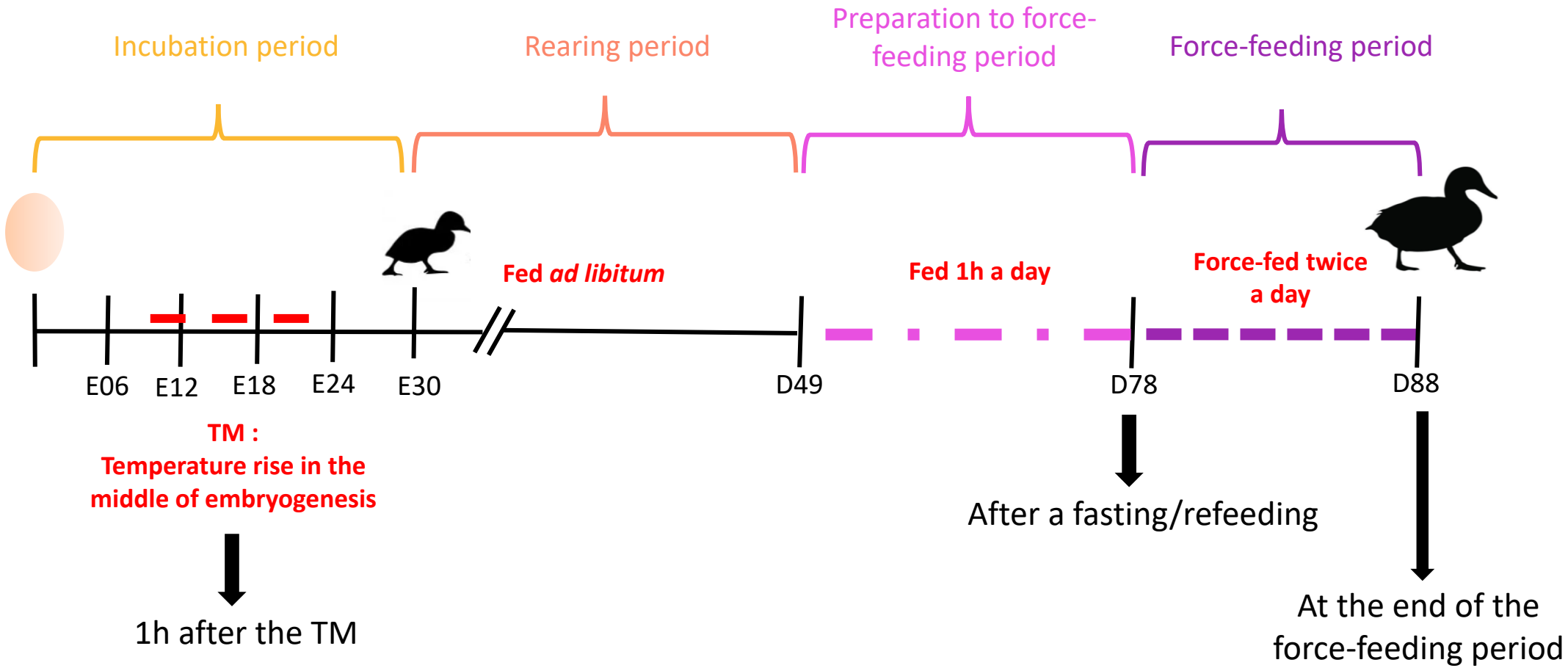
Mother nutrition
Hypoxy
Lighting programme
Temperature

A **Thermal Manipulation** is a change in temperature occuring during the embryogenesis

(Tarry-Adkins and Ozanne, 2011 ; Vaiserman, 2018)
(Archer et al., 2009; Haron, 2021; Andrieux et al., 2022)

Goal of the study

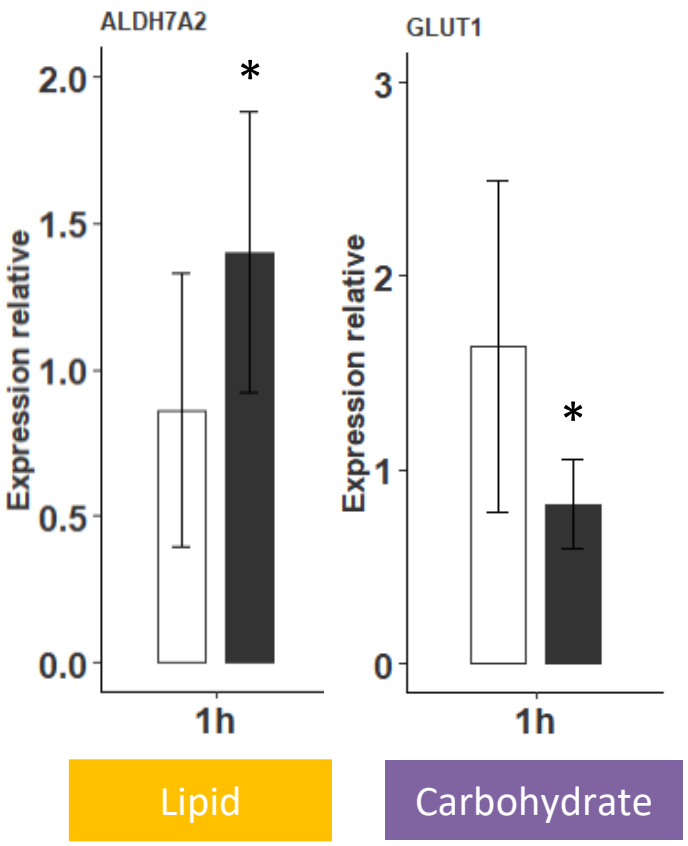
Evaluation of the impacts of the thermal manipulation throughtout the mule duck life



E : Embryonic day; D : day of life; TM : Thermal manipulation

Direct impact of the TM

TM ducks showed direct changes in the relative expression of genes involved in energy metabolism



TM : + 1°C, started à E13
AGE : E13 (Incubation period)
CONDITION : 1h after the increase of temperature

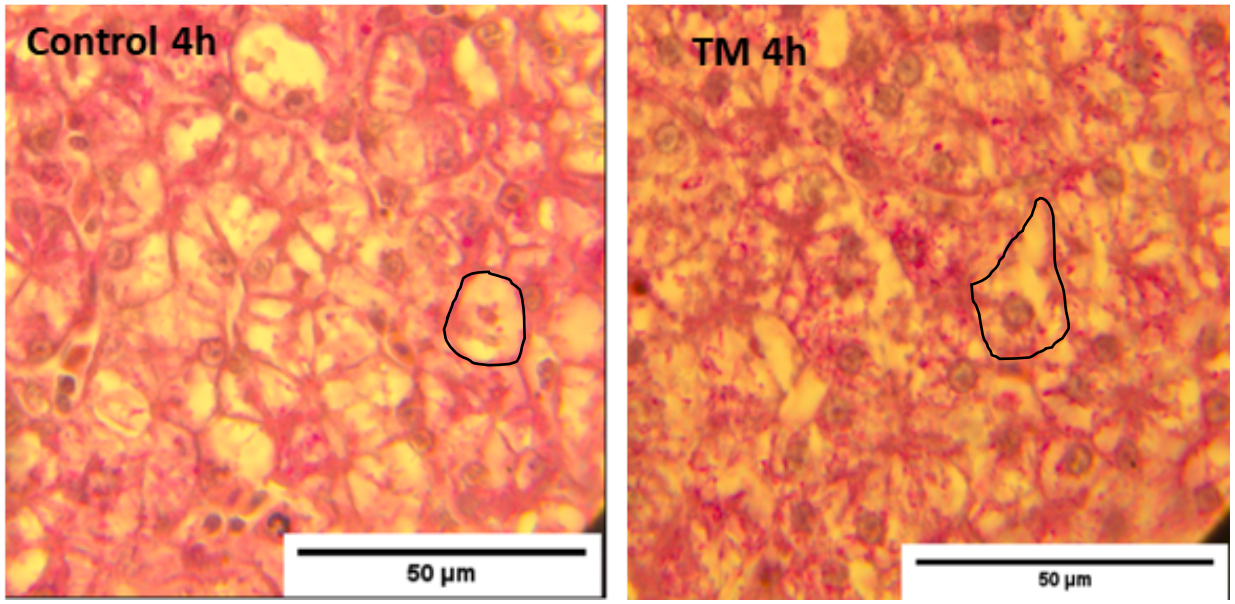
- **Change in the relative expression of genes involved in energy metabolism pathways**, as lipid or carbohydrate metabolisms (8 genes out of 78)
- ALDH7A2 : actor of lipid oxidation (production of energy from lipids)
- GLUT1 : transporter of glucose in tissue (entrance of glucose in the liver)

E : Embryonic day

Impacts on the hepatic metabolic response

The TM led to greater hepatocyte expansion and to altered energy storage after a meal

Liver histological sections



TM : + 1°C, E13-E27 16h/24
AGE : D78 (End of the force-feeding preparation period)
CONDITION : 4h after a meal, after a fasting of 23h

- Expansion of hepatocytes 4h after the refeeding
- **Expansion bigger** for TM ducks (+ 1µm²)
- **Change in liver lipid composition** (+ 4% of saturated fatty acids 4h after the meal in TM group)
- **Change in the relative expression of metabolic genes** involved in lipid or carbohydrate metabolisms (8 genes out of 80)

(Andrieux et al., 2023 in American Journal of Physiology)

TM : Thermal manipulation

Impact on the *foie gras* production

TM ducks presented higher liver weight and a change in energy metabolism response

TM : + 1.7°C, E11-E21 16h/24
AGE : D88 (End of the force-feeding period)
CONDITION : 2 and 10h after the last meal of force-feeding

	Control	Thermal manipulation
Body weight(g)	5917 ± 357	5842 ± 322
Liver weight (g)	601^{a} ± 100	653^{b} ± 111
HSI	10.2^{a} ± 1.7	11.2^{b} ± 1.8
Melting rate (%)	19.0 ± 12.3	21.9 ± 12.3
Total lipids in liver (%)	60.9 ± 4.8	67.2 ± 5.6
Number of ducks	36	58

- **Higher liver weight** for TM ducks after force-feeding (10h after the last meal)
- **Change in liver lipid composition** (10h after the last meal)
- **Increase of relative expression of genes** involved in lipid metabolism (2h after the last meal)

(Andrieux et al., 2023 in Frontiers in Physiology)

Conclusion

What are the consequences of a thermal manipulation at different stages in a duck's life ?

Incubation

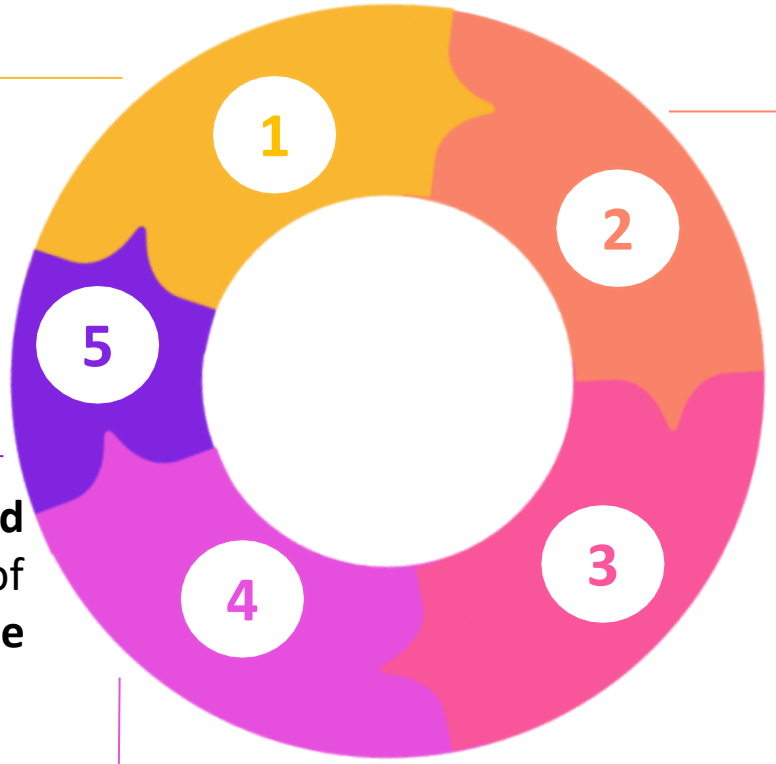
Direct impacts of the TM on relative expression of **genes involved in lipid and carbohydrate metabolisms**

(Andrieux et al., in preparation)

Force-feeding

Impacts on **liver weight, liver lipid composition** and relative expression of **genes involved in lipid and carbohydrate metabolisms**

(Andrieux et al.,2021; 2023 in Frontiers in Physiology)



At hatch and D6

Impacts on **weight at hatch** and **internal temperature at D6**

(Andrieux et al., 2022 in Animal)

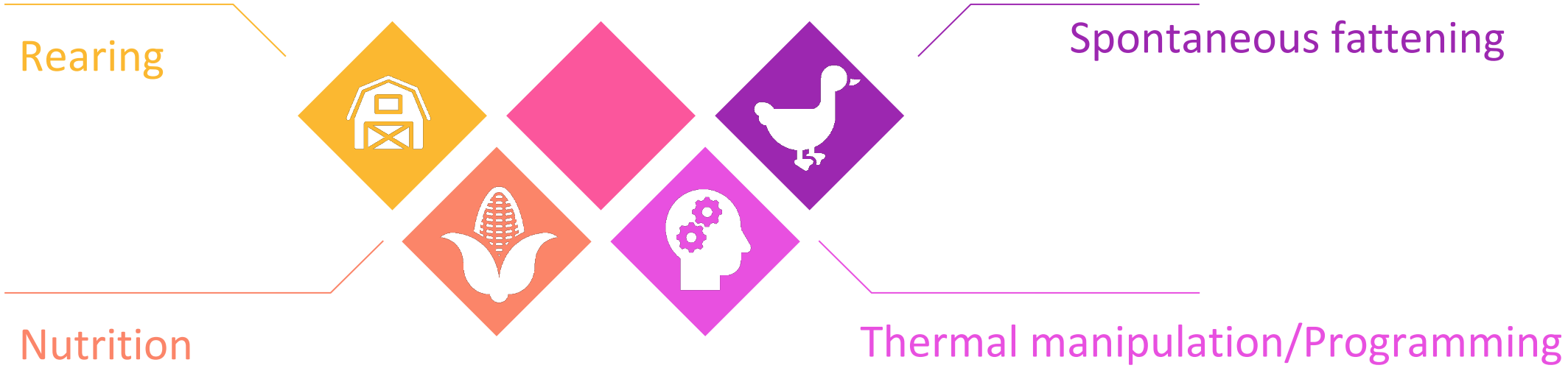
Force-feeding preparation

Impacts on **liver composition, size of hepatocytes** and relative expressions of **genes involved in lipid and carbohydrate metabolisms**

(Andrieux et al., 2023 in American Journal of Physiology)

Prospects

New prospects to improve the foie gras production field



- By combining techniques that have already been optimised with thermal manipulaion, we could move towards **optimising the duration of force-feeding** and/or **alternatives to force-feeding** (spontaneous fattening).
- Tool to improve **resistance to diseases** or to **heat stress** (ex: in broilers)

Aknowledgements

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Le marsan agglomération

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CIFOG INTERPROFESSION DU FOIE GRAS

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Thank you for your attention

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