

## Short communication

# FLEXIBLE DUODENAL MONOCANNULA OF THE NATIONAL AGRICULTURAL AND FOOD CENTRE DESIGN FOR THE DETERMINATION OF INTESTINAL NUTRIENT DIGESTIBILITY IN CATTLE

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## ABSTRACT

Research in physiology of ruminant nutrition using the *in sacco* and mobile bag methods and developing and testing of a duodenal cannula of our own construction including our own surgical application in cattle, led to the intellectual property protection. The duodenal monocannula for determination of nutrient intestinal digestibility in cattle, designed by the National Agricultural and Food Centre (NPPC, Slovak Republic), has been registered by European Union intellectual property office, as a Registered Community Design. The innovativeness of the technical design of the "NPPC cannula" lies in the fact that the cannula is made of one piece of a straight tube with an inner diameter of 22 mm. The tube is smooth, with no additional extensions and glued parts. The operation does not require ligation of the bowel with an arterial prosthesis or a polyurethane felt. The dimensions of the cannula allow the use of the mobile bag method without any problems. The vinyl chloride emulsion was designed to polymerize at the lower temperature, than has been currently used in this procedure (130 °C), and the end used for fixation in the intestine could be shaped after immersion in warm water. During the growth of the animals, the tube length can be prolonged to adapt to the duodenal size. As a result, the life of cannulated animals can be extended without age limitation.

**Key words:** flexible monocannula; duodenum; mobile bag method; cattle; IP protection

## INTRODUCTION

Cost-efficient and sustainable animal production is an essential component for food industry. Animal production can lower its footprint by precision nutrition, which increases nutrient utilization, reduces nutritional disorders and ammonia emissions. Determination of changes in the rumen degradability and intestinal digestibility of protected and non-protected nutrients, feeds, is a prerequisite for reducing the release of ammoniac nitrogen. Results of the degradability and intestinal digestibility of individual nutrients help to set the feed rations of cattle within the framework

of precise nutrition, so that there is no unnecessary excretion of nutrients into the environment. This is the reason why it is important to monitor the nutritional characteristics (Rajský, Polovka, 2023).

Cannulated ruminants, which enable the use of the mobile bag method, are necessary to determine predicted intestine-enzymatic or total digestibility of feed after 24 h incubation in the rumen (Chrenková *et al.*, 2012). For various categories and sizes of animals, as well as for various sections of the intestine, a wide range of cannulas are offered. Duodenal cannulation is a second step after rumen cannulation (Szakács *et al.*, 2021). This research technique allowed a long-term use

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of experimental animals (Chrenková *et al.*, 2018).

Mobile bag method helps to test properties of feed as a form of cooperation between feed manufacturers and research. The aim of the producing of protected feeds is to allow the retention of biological activity of transferred substances and their release in the small intestine, where they are better utilized for the animal's needs and, therefore, important for economy, as well. Increased production efficiency can help solving human food deficiency. This generates significant social impact of this research. The originality of the research lies, in addition to the already mentioned aspects, in the use of the unique *in sacco* and mobile bag method on cannulated cows and using of a duodenal cannula of our own construction including our own surgical application. Further research will translate into reducing the use of antibiotics in livestock production and, hereby, contribute to the safe animal nutrition for healthy human food.

For duodenal cannulation in cattle, re-entrant cannulas were initially used, which allowed the collection of the total flow of the chyme. In addition to the fact that the application of such cannulas involved resection of the intestine, the use of animals was also time-consuming, staff-intensive and costly. Therefore, they gradually switched to simpler methods and started using T-cannulas. The simplification of techniques not only made it easier to work with experimental animals but was also in line with increasingly stringent European and national legislation dealing with animal protection (Szakács *et al.*, 2021). Previously, only solid cannulas (steel, titanium, plexiglass and others) were used. Later, soft materials such as polyvinyl chloride, silicone, teflon, polyurethane, dacron, polyethylene, or polycarbonate were also used (Harmon, Richards, 1997).

The aim of the present short communication was to describe the characteristics and in-field application of the flexible duodenal cannula covered by intellectual property (Registered Community Design) at the NPPC Institute.

## MATERIAL AND METHODS

Polyvinyl chloride containing stabilisers and plasticizers were used as the material for the cannula. To produce cannulas, the emulsion form is the most suitable. Stabilisers increase temperature resistance up to 200 °C, and softeners ensure the elasticity.

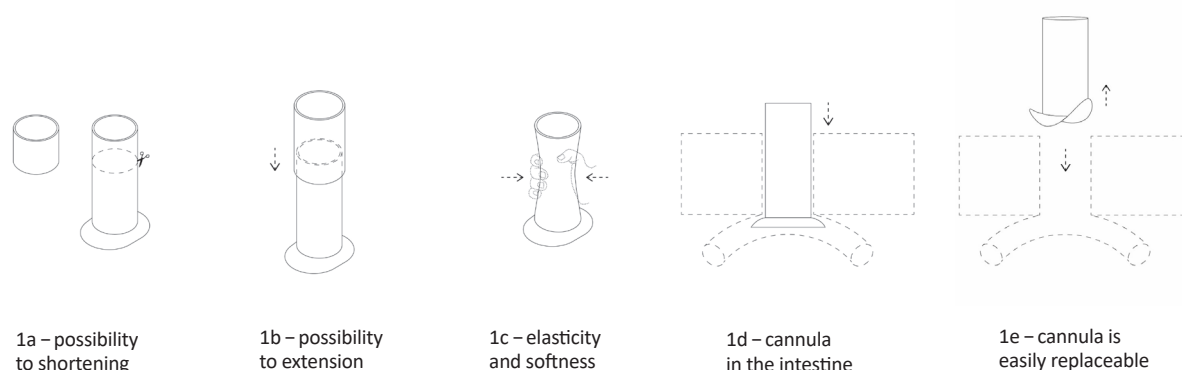
The cannulas are prepared by polymerization after application of the emulsion to glass matrices with a brush (50 ml glass graduated cylinder) in layers. This matrix is inserted into a glass petri dish, which allows a significant expansion of the fixation base of the cannula and, thus, a more secure fixation in the intestine. Polymerization of 26–30 layers is carried out at a temperature of 140 °C for 10–15 minutes. It is necessary to prepare an extended fixation base of the cannula into the shape of an oval. It is important to ensure that it is smooth, to exclude mechanical irritation of the intestinal epithelium. The cannulas temporarily soften after insertion into hot water, they are mouldable and flexible. This facilitates insertion of the fixation base into the intestinal lumen during surgery even with minimal incision of the intestinal wall. This allows easy and painless replacement of the cannula with a new one in case of damage. However, after several years, the hardening of the fixation base may occur.

The cannula consists of a tube and an oval-shaped fixation base. Inner diameter of the tube is 21 mm, wall thickness 0,3–0,5 mm, length of the tube 100–120 mm. Length of the fixation base is 55 mm, width 45 mm.

## RESULTS AND DISCUSSION

Research using cannulated cows by *in sacco* and mobile bag methods in the Laboratory of Physiology of Ruminant Nutrition led to develop a duodenal cannula of our own construction including our own surgical application in animals. The cannula is characterised by a specific shape composed of an ellipsoidal base and a cylindrical body. The surface of the cannula is smooth, without protrusions and folds. The cannula is made of a material, which is flexible and allows the cannula to be shortened or lengthened (Figure 1). The flexible cannula is easy to apply into the body. The cannula does not damage the mucous membranes of the animal during surgery and laboratory monitoring. The duodenal monocannula for nutrient intestinal digestibility determination in cattle, designed at the National Agricultural and Food Centre, has been registered by European Union intellectual property office, as a Registered Community Design in 2023.

Our aim was to construct the simplest possible duodenal cannula to enable the use of the mobile bag method to determine total and intestinal nutrient digestibility in cattle. When selecting a suitable cannula



**Figure 1. Flexible duodenal monocannula for determination of nutrient intestinal digestibility in cattle**

material, we assessed properties such as stability at changing temperatures, pH changes and toxicity during production and use. The priority were the elasticity and softness after immersion in hot water.

We opted for softened vinyl chloride in emulsion form, which can also be polymerised on site with no extra cost. The only necessary things are a hot air sterilizer and appropriately selected matrices.

The polyvinyl chloride cannula was used in the past by Ash (1962). However, the authors applied a re-entrant cannula, used for continuous collection of intestinal chyme in sheep. In 2023, the option to order a fixed closed silicone T-cannula from Bar Diamonds Inc. (Idaho, USA), that was manufactured according to design by Komarek (1983), expired. Due to the unavailability of suitable flexible open T-cannulas on the market, we designed our own technical solution. Currently, only Teflon flexible rumen fistulas are produced. The literature (Ivan *et al.*, 1985; Plascencia *et al.*, 2013; Li *et al.*, 2022 and others) mentions a few more duodenal cannulas, but either the authors did not describe the parameters, or the cannulas do not reach the characteristics of our technical solution allowing its use in cattle for at least 10 years.

This is a device that allows the periodic insertion of bags into the intestine. As the first advantage of this cannula, the simplification of the surgical procedure itself and the minimization of post-operation complications should be mentioned. All used duodenal cannulas have a fixation extension on the tube for sewing a dacron vascular prosthesis or polyurethane felt (mash) for better fixation of the cannula base in the intestine. Using such a material, they insert an additional layer between the intestinal wall and the

peritoneum, assuming that these materials will grow through the fibrin while isolating the intestinal wall from the peritoneum. Although these materials are assumed and declared to be inert, especially when used in vascular surgery as an artificial replacement of a damaged blood vessel, in abdominal surgery they behave like a foreign body that the body wants to reject. This reduces the survival of the operated animals. In our flexible cannula, we pursue the opposite goal of making the intestinal wall firmly fused with the peritoneum and abdominal wall forming a rigid ligamentous ring. Therefore, we designed a plain tube without the extension of the fixation ring. Cannula is, thus, easily replaceable. This is an advantage after mechanical damage, or when the animal grows, where the abdominal wall is thickened. Pulling out a soft and flexible cannula does not cause injury to the animal, as in the case of other types of cannulas, when the removal of the cannula means that the animal must be euthanized. The advantage is that it can be produced by yourself. All you need is a hot air dryer and simple dies (glass measuring cylinders and petri dishes). Rigid and multi-component cannulas are heavy and irritate the dermal ligamentous ring around the tube, which is associated not only with the formation of wound effusion, but also with leakage of intestinal chyme onto the skin. In these cannulas it is necessary to treat the skin around the tube daily to prevent irritation and chronic inflammation due to the acidic intestinal juice with pH 2.5–3.0, or other complications.

The cannulated cows are used for experimental work in the accredited Laboratory of Ruminant Nutritional Physiology (SK U 03021), National Agricultural and Food Centre, Research Institute for Animal Production Nitra.

The laboratory is involved in international and national projects as well as in the implementation of feed tests ordered from enterprises. Laboratory and the used methods allow long-term involvement in international and national projects, such as EU Project: Silegenequa QLK5-CT-2001-01262, in the 5<sup>th</sup> Framework program of EU, EU Project REDNEX 211606, in the 7<sup>th</sup> Framework program of EU, EU Project H2020 NanoFEED, ID 778098 Nanostructured carriers for improved cattle and dozens of other projects.

## CONCLUSIONS

The characteristics of the registered duodenal monocannula, used for determination of nutrient intestinal digestibility in cattle, validate the usefulness of design for: 1) small weight not causing traction on tissues (elimination of chyme discharge, skin irritation, mucous membrane damage, intestinal wall puncture), 2) the replacement after extraction without the need for re-operation, 3) the possibility of cannula extension during the growth of the animal, which allows cannulated cow use without time limitation; we used the cannulated cows for a long time, even at the age of 15 years of their life, 4) internal translucency of the cannula tube (22 mm), that allows convenient insertion of the mobile bags into the duodenum according to the methodology so as not to damage the weld. The bags filled with the tested feed are inserted into the intestine with gentle pressure. The bags are inserted in time series in accordance with the displacement of the chyme in rhythmic periods of approximately 15 minutes (opening the pylorus of the abomasum).

The innovativeness of the technical design of the NPPC cannula lies in the fact that the cannula is made of one piece of a straight tube with an inner diameter of 22 mm. The tube is smooth, with no additional extensions and glued parts. The operation does not require ligation of the bowel with an arterial prosthesis or a mash. The dimensions of the cannula allow the use of the mobile bag method (for which purpose it was manufactured) without any problems. The vinyl chloride emulsion was designed to polymerize at the lower temperature, than has been currently used in this procedure (130 °C), and the end used for fixation in the intestine could be shaped after immersion in warm water. During the growth of the animals, the tube length can be prolonged to adapt to the duodenal

size with an extension from the tube of a disposable syringe. As a result, the life of cannulated animals can be extended without age limitation.

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## AUTHOR'S CONTRIBUTIONS

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All authors have read and agreed to the published version of the manuscript.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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