NATIONAL AGRICULTURAL AND FOOD CENTRE
RESEARCH INSTITUTE FOR ANIMAL PRODUCTION NITRA

The 4th International Scientific Conference "Animal Biotechnology"
Slovak J. Anim. Sci., 49, 2016 (4): 157–159

ISSN 1337-9984

SOME ASPECTS OF POULTRY BIOTECHNOLOGY: A REVIEW

M. BEDNARCZYK

Department of Animal Biochemistry and Biotechnology, UTP University of Science and Technology, Bydgoszcz, Poland

ABSTRACT

Animal biotechnology is the application of scientific and engineering principles to the processing or production of materials by animals to provide goods and services. Sometimes the animal biotechnology has been limited to genetic-based biotechnology only. However, the animal biotechnology uses the other, different techniques, such as artificial insemination, embryo transfer, *in vitro* fertilization, embryo culture, cloning by nuclear transfer from embryonic or adult somatic cell, etc. Due to the specificity of embryonic development in birds, which occurs inside the egg, the growing embryo can be directly manipulated via a window that is cut on the eggshell at a very early embryonic stage. This fact was used to develop *in ovo* technology – direct administration of a bioactive substance suspended in a solution to the incubating egg. This review integrates recent progress and new insights into methods of transgenic bird production (A), and possibility to modify the avian development (B).

Key words: chicken; biotechnology; transgenesis; *in ovo*

INTRODUCTION

A. Avian transgenesis

The production of transgenic birds has been hampered by the yolk-laden structure of the ovum and their unique reproductive system. The transgenic chickens have been produced by two different procedures, in general. The first is based on the viral transfection systems and the second non-viral, uses the genetically modified embryonic cells, transferred directly into the recipient embryo. Although viral transfection systems allows for efficient introduction and expression of transgenes in chicken dividing and non-dividing cells also (McGrew *et al*., 2004), they have some important limitations: (i) restriction in the size of the vector genome to less than 8 to 10 kb (Byun *et al*., 2011), (ii) vector insertion can cause the disruption of endogenous genes by insertional mutagenesis or the transactivation of neighboring endogenous genes (Li and Lu, 2010), (iii) integrated lentiviral vectors are subject to positional effects (Yi *et al*., 2011). However, the much more important limitation is a public concern, which has questioned the safety of lentivirus-based technology. In this situation some alternative strategies were developed, and the idea of generation of transgenic chicken through chimeric intermediates was described (Raynaud, 1976; Petitte *et al*., 1990). The generation of transgenic chickens has been attempted through chimeric intermediates produced by the transfer of blastodermal cells. The same idea was proposed in many other experiments, however in this case primordial germ cells (PGC), precursors of gonads, were proposed as the vehicle for introduction the transgene into the chicken genome. PGCs are especially increasingly being used in research on the development of chicken bioreactor. Chicken bioreactors provided, among others, human erythropoietin (Koo *et al*., 2010), interferon alpha- 2b (Rapp *et al*., 2003), interferon beta-1a (Lillico *et al*., 2007), monoclonal antibodies (Kamihira *et al*., 2005), granulocyte colony stimulating factor (G-CSF) (Kwon *et al*., 2008). Genetic modifications may also be used in reducing the negative impact of poultry

Correspondence: E-mail: bednarczyk@utp.edu.pl
Marek Bednarczyk, Department of Animal Biochemistry and Biotechnology,
UTP University of Science and Technology,
85-084 Bydgoszcz, Poland

Received: October 10, 2016
Accepted: October 24, 2016

production on environment condition. Introduction of salivary phytase transgenes into chicken can solve the problem of environmental pollution with phosphorus, by forcing its distribution in the body of animal (Sang, 2003).

Now, the novel, promising strategy, allowing efficacious enrichment of manipulated chicken PGCs on the basis of genome editing, has been proposed (Park *et al.*, 2014; Oishi *et al*., 2016). Highly efficient and precise genome editing tools are actively adapted in poultry species, and in the near future will create the new bioindustry in poultry (Han *et al*., 2016).

B. Modification of avian development

Generally, *in ovo* method enables the administration of a bioactive substance: carbohydrates, fatty acids, amino acids, minerals, vitamins, nanoparticles, prebiotics, probiotics or synbiotics directly to the incubating egg. As a consequence, *in ovo* delivery of bioactives not only have improved performance traits, such as the growth rate, feed intake, nutrient digestibility (Ohta *et al*., 1999; Bednarczyk *et al*., 2011) and meat quality (Maiorano *et al*., 2012), but also significantly increased activity of some enzymes (Liu *et al*., 2013; Pruszynska-Oszmalek *et al.*, 2015) and influenced immune system development and function (Bhanja and Mandal, 2005; Bakyaraj *et al*., 2012; Slawinska *et al.*, 2014; Madej and Bednarczyk, 2016; Madej *et al.*, 2015; Plowiec *et al*., 2015).

CONCLUSION

Thanks to these new techniques of cells isolation, manipulation and modification, as well as thanks to *in ovo* embryogenesis modification, bird biotechnology has had, and will also certainly have in future, important place in the improvement of animal health and productivity.

ACKNOWLEDGEMENTS

This work was partially financed by grant no. N R12 0110 10 and grant no. PBS3/A8/30/2015 from the National Centre for Research and Development (Poland).

REFERENCES

BAKYARAJ, S. – BHANJA, S. K. – MAJUMDAR, S. – DASH, B. 2012. Modulation of post-hatch growth and immunity through *in ovo* supplementated nutrients in broiler chickens. *Journal of the Science of Food Agriculture*, vol. 92, 2012, p. 313–320.

BEDNARCZYK, M. – URBANOWSKI, M. – GULEWICZ, P. – KASPERCZYK, K. – MAIORANO, G. – SZWACZKOWSKI, T. 2011. Field and *in vitro* study on prebiotic effect of raffinose family oligosaccharides in chickens. *Bulletin of the Veterinary Institute in Pulawy*, vol. 55, 2011, p. 465– 469.

BHANJA, S. K. – MANDAL, A. B. 2005. Effect of *in ovo* injection of critical amino acids on pre- and post-hatch growth, immunocompetence, and development of digestive organs in broiler chickens. *Asian Australasian Journal of Animal Science*, vol. 18, 2005, p. 524–531.

BYUN, S. J. – KIM, S. – KIM, K. W. – KIM, J. S. – HWANG, I. S. – CHUNG, H. K.– KAN, I. S.– JEON, I. S. – CHANG, W. K. – PARK, S. B. – YOO, J. G. 2011. Oviduct-specific enhanced green fluorescent protein expression in transgenic chickens. *Bioscience, Biotechnology and Biochemistry*, vol. 75, 2011, p. 646–649.

HAN, J. Y. – LEE, H. J. – HWANG, Y. S. – PARK, Y. H. – LEE, B. R. 2016. Genome editing and its applications in poultry. *The Proceedings of XXV World's Poultry Congress*, L66, 2016, p. 328-333.

KAMIHIRA, M. – ONO, K. – ESAKA, K. – NISHIJIMA, K. – KIGAKU, R. – KOMATSU, H. – YAMASHITA, T. – KYOGOKU, K. – IIJIMA, S. 2005. High-level expression of single-chain Fv-Fc fusion protein in serum and egg white of genetically manipulated chickens by using a retroviral vector. *Journal of Virology*, vol. 79 (17), 2005, p. 10864–10874.

KOO, B. C. – KWON, M. S. – LEE, H. – KIM, M. – KIM, D. – ROH, J. Y. – PARK, Y. – CUI, X. – KIM, N. – BYUN, S. J. – KIM, T. 2010. Tetracycline-dependent expression of the human erythropoietin gene in transgenic chickens. *Transgenic Research*, vol. 19, 2010, p. 437–447.

KWON, M. S. – KOO, B. C. – CHOI, B. R. – PARK, Y. – LEE, Y. M. – SUH, H. S. – PARK, Y. S. – LEE, H. T. – KIM, J. – ROH, J. Y. – KIM, N. – KIM, T. 2008. Generation of transgenic chickens that produce bioactive human granulocyte-colony stimulating factor. *Mollecular Reproduction and Development*, vol. 75, 2008, p. 1120–1126.

LI , J. – LU, L. 2010. Recent progress on technologies and applications of transgenic poultry. *African Journal of Biotechnology*, vol. 9 (24), 2010, p. 3481–3488.

LILLICO, S. G. – SHERMAN, A. – MCGREW, M. J. – ROBERTSON, C. D. – SMITH, J. – HASLAM, C. – BARNARD, P. – RADCLIFFE, P. A. – MITROPHANOUS, K. A. – ELLIOT, E. A. – SANG, H. M. 2007. Oviduct-specific expression of two therapeutic proteins in transgenic hens. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 104, 2007, p. 1771–1776.

LIU, P. – HU, Y. – GROSSMANN, R. – ZHAO, R. 2013. *In ovo* leptin administration accelerates post-hatch muscle growth and changes myofibre characteristics, gene expression and enzymes activity in broiler chickens. *Journal of Animal Physiology and Animal Nutrition*, vol. 97, 2013, p. 887–895.

MADEJ, J. P. – BEDNARCZYK, M. 2016. Effect of *in ovo*-delivered prebiotics and synbiotics on the morphology and specific immune cell composition in the gut-associated lymphoid tissue. *Poultry Science*, vol. 95, 2016, p. 19–29.

MADEJ, J. P. – STEFANIAK, T. – BEDNARCZYK, M. 2015. Effect of *in ovo* delivered prebiotics and synbiotics on lymphoid organs morphology in chickens. *Poultry Science*, vol. 94, 2015, p. 1209–1219.

MAIORANO, G. – SOBOLEWSKA, A. – CIANCIULLO, D. – WALASIK, K. – ELMINOWSKA-WENDA, G. – SŁAWINSKA, A. – TAVANIELLO, S. – ZYLINSKA, J. – BARDOWSKI, J. – BEDNARCZYK, M. 2012. Influence of *in ovo* prebiotic and synbiotic administration on meat quality of broiler chickens. *Poultry Science*, vol. 91, 2012, p. 2963–2969.

MCGREW, M. J. – SHERMAN, A. – ELLARD, F. M. – LILLICO, S. G. – GILHOOLEY, H. J. – KINGSMAN, A. J. – MITROPHANOUS, K. A. – SANG, H. 2004. Efficient production of germline transgenic chickens using lentiviral vectors. *EMBO Reports*, vol. 5, 2008, p. 728–733.

OHTA, Y. – TSUSHIMA, N. – KOIDE, K. – KIDD, M. T. – ISHIBASHI, T. 1999. Effect of amino acid injection in broiler breeder eggs on embryonic growth and hatchability of chicks. *Poultry Science*, vol. 78, 1999, p. 1493–1488.

OISHI, I. – YOSHII, K. – MIYAHARA, D. – KAGAMI, H. – TAGAMI, T. 2016. Targeted mutagenesis in chicken using CRISPR/Cas9 system. *Science of Reproduction*, vol. 6, 2016, doi: 10.1038/srep23980.

PARK, T. S. – LEE, H. J. – KIM, K. H. – KIM, J. S. – HAN, J. Y. 2014. Targeted gene knockout in chickens mediated by TALENs. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 111, 2014, p. 12716–12721.

PETITTE, J. N. – CLARK, M. E. – LIU, G. – VERRINDER GIBBINS, A. M. – ETCHES, R. J. 1990. Production of somatic and germline chimeras in the chicken by transfer of early blastodermal cells. *Development*, vol. 108, 1990, p. 185–189.

PLOWIEC, A. – SLAWINSKA, A. – SIWEK, M. – BEDNARCZYK, M. 2015. Effect of *in ovo* administration of inulin and *Lactococcus lactis* on immune-related gene expression in broiler chickens. *American Journal of Veterinary Research*, vol. 76, 2015, p. 975–982.

PRUSZYNSKA-OSZMALEK, E. – KOLODZIEJSKI, P. A. – STADNICKA, K. – SASSEK, M. – CHALUPKA, D. – KUSTON, B. – NOGOWSKI, L. – MACKOWIAK, P. – MAIORANO, G. – JANKOWSKI, J. – BEDNARCZYK, M. 2015. *In ovo* injection of prebiotics and synbiotics affects the digestive potency of the pancreas in growing chickens. *Poultry Science*, vol. 94, 2015, p. 1909–1916.

RAPP, J. C. – HARVEY, A. J. – SPEKSNIJDER, G. L. – HU, W. – IVARIE, R. 2003. Biologically active human interferon α-2b produced in the egg white of transgenic hens. *Transgenic Research*, vol. 12, 2003, p. 569–575.

RAYNAUD, G. 1976. Reproductive capacity and offspring of chickens submitted to transfer of primordial germ cells during embryonic life. *Roux's Archive of Developmental Biology*, vol. 179, 1976, p. 85–110.

SANG, H. 2003. Genetically modified livestock and poultry and their potential effects on human health and nutrition. *Trends in Food Science and Technology*, vol. 14, 2003, p. 253–263.

SLAWINSKA, A. – SIWEK, M. Z. – BEDNARCZYK, M. F. 2014. Effects of synbiotics injected *in ovo* on regulation of immune-related gene expression in adult chickens. *American Journal of Veterinary Research*, vol. 75, 2014, p. 997–1003.

YI, Y. – NOH, M. J. – LEE, K. H. 2011. Current Advances in Retroviral Gene Therapy. *Current Gene Therapy*, vol. 11 (3), 2011, p. 218–228.