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Introduction:

Hair loss has limited pharmacological treatment and there are enormous demands for hair growth. Currently, only two medicines, minoxidil and finasteride, have been approved by the US Food and Drug Administration (FDA) for the treatment of hair loss [1]. Nevertheless, due to its gender limitation and side effects, it is very important to develop new therapeutic and cosmetic agent to prevent hair loss.

Hairs are generally consisted of two parts based on the epidermis, the upper part is the hair shaft and the lower is hair follicle (HF). HFs are intricate structure composed of the dermal papilla (DP) and dermal sheath (DS) [2]. Dermal papilla cells (DPCs), a cluster of mesenchymal derived cells, are situated at the bottom of HF and considered as main components of HFs, which are responsible for the regulation of hair cycle as well as the maintenance and induction of the hair growth [3-4].

Numerous studies reported that vascular endothelial growth factor (VEGF), fibroblast growth factor 7 (FGF7) and hepatocyte growth factor (HGF) in DPCs and hair biology are known to regulate hair morphogenesis and hair growth [5-7]. Also, Wnt/ β -catenin signaling is well established pathway in the growth of HF [8]. Moreover, Ser9 phosphorylated glycogen synthase kinase (GSK)-3 β , which is inactivated form, is also known as inducing the accumulation of β -catenin [9].

Soybean (*Glycine Soja* Siebold et Zucc.), one of most excellent sources of protein, is also known as the main dietary sources of phytoestrogen, soy isoflavones [10]. It has been reported that the extract of soybean increased hair length in mice [11], but not the effect of soybean embryo extract has been reported yet.

The purpose of this study was to evaluate the effects of SOYACT, newly developed soybean embryo extract, on the prevention of hair loss and promotion of hair growth. Along with the *in vitro* assay, here, we also performed the hair growth *ex vivo* human organ culture and clinical trial to strongly prove our hypothesis.

Materials & Methods:

► Preparation of extract

- Dried embryo of a *Glycine Soja* Siebold et Zucc was collected in Paju, Gyeonggi-do, South, Korea. The dried embryos of a *Glycine Soja* were extracted from 10kg of 30%(w/w) ethanol at 60°C for 3 h and filtered to obtain 8.5 kg of filtrate. Subsequently, the filtrate was passed through HP20 and all the fluids wiped with 50% (w/w) soluble ethanol were combined. And the filtrate was further concentrated to obtain 600g of crude extract containing 4% of solids. The same amount of 1,3-Butylene Glycol was added to the above crude extract and mixed and the final 1kg of extract was obtained.

► Efficacy Test on Cell

● Cell Line

- Human Follicle Dermal Papilla Cells (HFDP)

● Cell Proliferation Assay

- 3-[4, 5-dimethylthiazol-2-yl]-2, 5-diphenyltetrazolium bromide (MTT)

● Evaluation of Gene Level

- Real-time RT-PCR

● Evaluation of Protein Level

- Western blot analysis

► Efficacy Test on Human Follicle Organ

● Organ Culture

- Human Follicle Organ culture under the approval of the Institutional Review Board of Dankook University Medical Center (IRB No. DKUH 2017-07-003)

● Evaluation of Hair Growth

- Hair follicle length photographed using a stereomicroscope

► Clinical trial study

● Study design

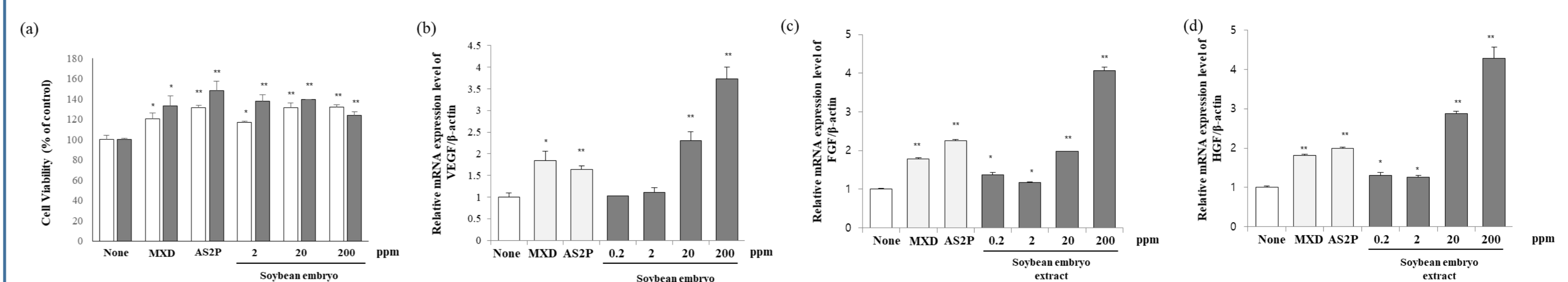
- Randomized, double-blind, placebo-controlled clinical trial
- Global Medical Research Center under the approval of the Institutional Review Board (GMRC, IRB no. GIRB-19819-AF)
- 50 volunteers, 18 to 54 years of age with androgenetic alopecia
- 2% soybean embryo extract shampoo for 24 weeks

● Evaluation of Hair Density

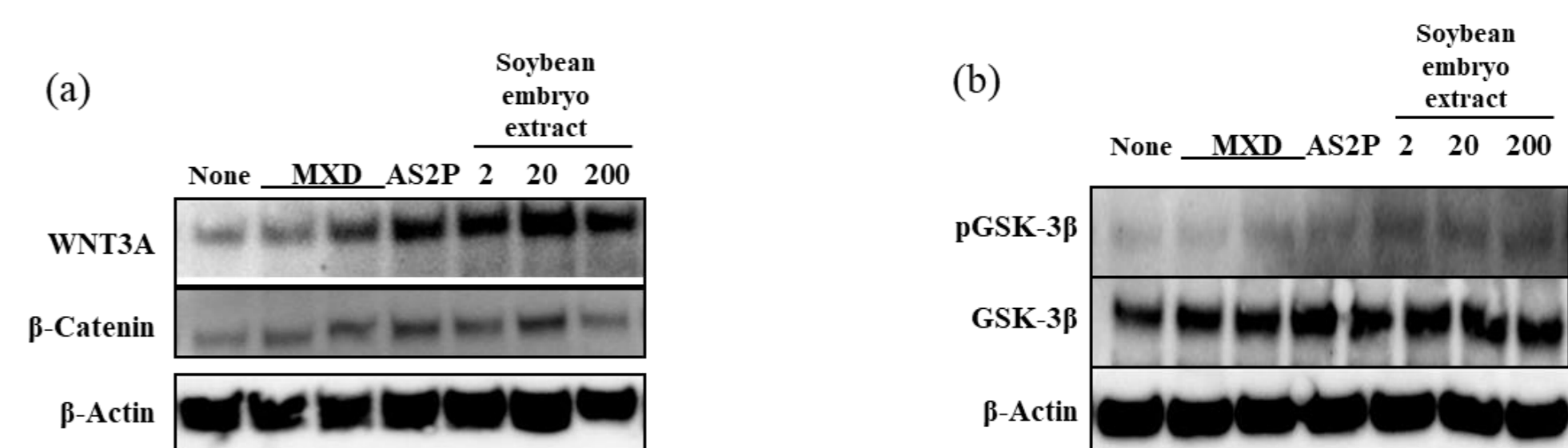
- Hair Density photographed using trichoscopic photograph

Results & Discussion:

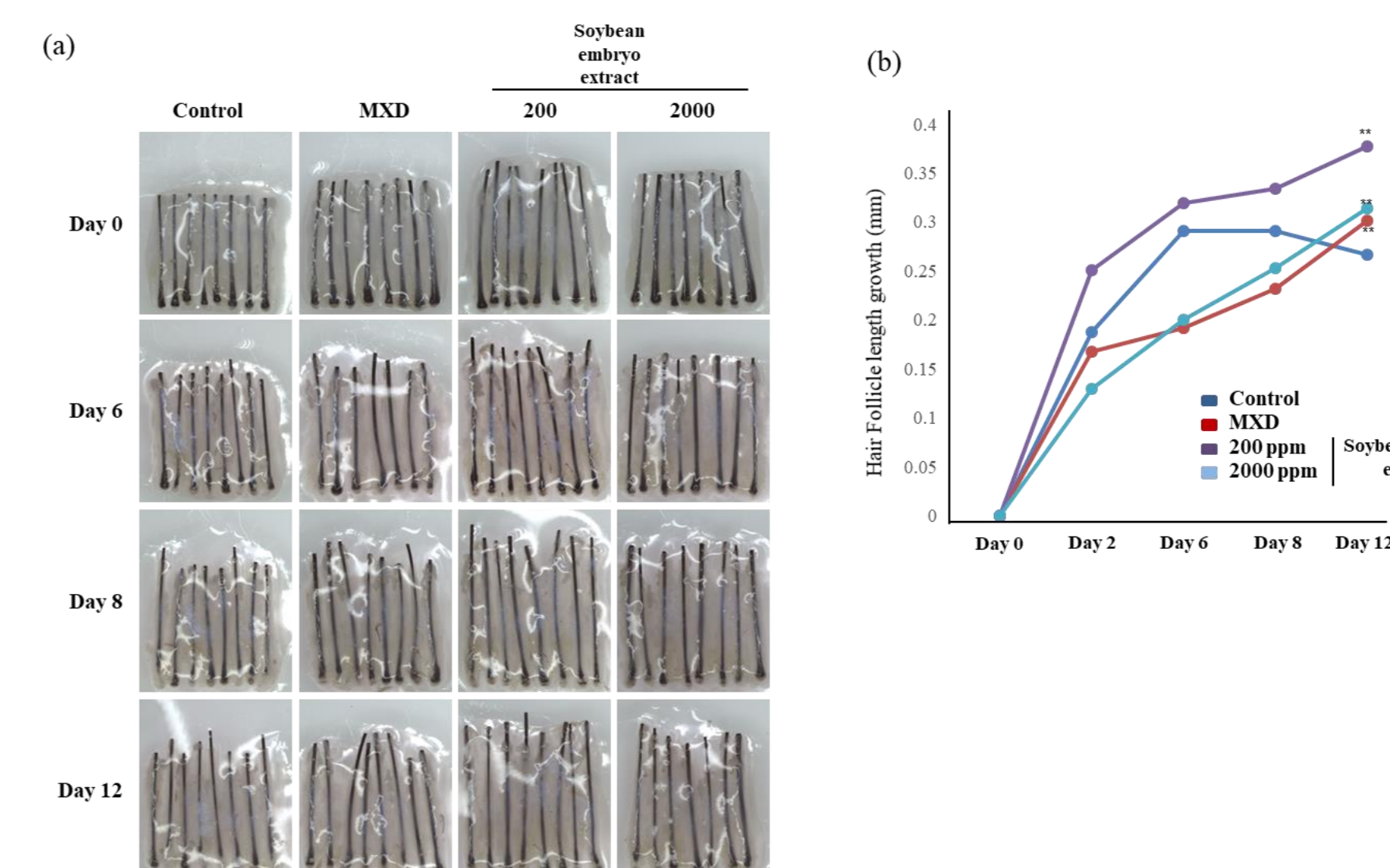
◆ Effects of soybean embryo extract on cell proliferation and hair growth factor expressions in DPCs



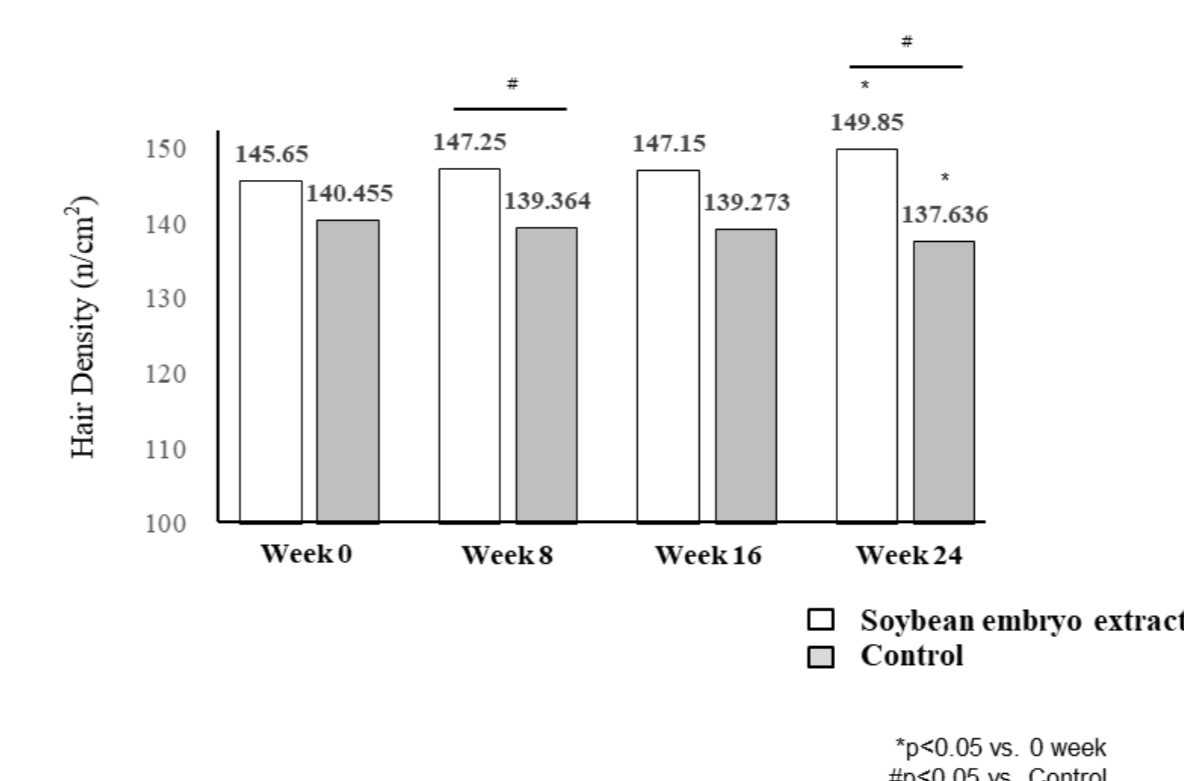
◆ Soybean embryo extract upregulates the Wnt/ β -catenin pathway in DPCs



◆ Soybean embryo extract increases hair growth in human HF organ culture



◆ Soybean embryo extract increases hair density in human scalp



Conclusions:

- We determined that Soybean embryo extract induced DPCs proliferation *in vitro*, hair elongation *ex vivo* HF organ, and increased hair density in clinical trial, providing evidence that Soybean embryo extract has anti hair loss effect and acts as hair growth enhancer.
- Furthermore, Wnt and β -catenin signaling pathway regulating the maintenance of anagen phase as well as hair growth cycle, is also activated by Soybean embryo extract, as well as GSK-3 β phosphorylation.
- Overall, these findings delineate the new insight for Soybean embryo extract in hair growth and anti-hair loss functions, showing that it would be a powerful hair growth ingredient for alleviating hair loss.

Aknowledgments:

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