A Review and Current Research on Biomaterials Supporting Artificial Insemination Technology Advancement

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ABSTRACT
The development of artificial insemination (AI) technology today plays an important role in the animal husbandry industry. The technology involves the enhancement of AI processes as well as improvement related to supporting biomaterials. A brief systematic literature review was aimed at proposed research problems in order to make the current development of artificial insemination becomes more effective and efficient as well as productive in securing our sustainable food. The study found that AI has still a lack in effectiveness and cost because of cryopreservation needs freezing step using liquid nitrogen. We proposed that developing better techniques and biomaterials supporting AI, can be not only low cost but also eco-friendly; thus, they contribute to the sustainable development of food for all people leading to the human beings as well as animal welfare.

Keywords: *artificial insemination, biomaterial, AI process.*

1. INTRODUCTION

One of the major developments of animal breeding is artificial insemination (AI) because of its important role in genetic improvement, genetic resource conservation, and productivity in animal husbandry. AI technology is a part of reproductive technologies besides multiple ovulation and embryo transfer (MOET), and in vitro embryo production (IVEP), which can lead to genetic improvement of animal husbandry and also has a major role to conserve animal genetic resources for all of the major domesticated species [1]. As an effective assisted reproductive technology, AI can also ensure global food security through sustaining the productivity of ruminant livestock because of its ability to up-cycle non-human-edible products into meat and milk products with notable nutritional value [2]. Hence, the advancement of AI technology is a strategic way for our global food security.

The development of AI technology involves the enhancement of AI processes as well as improvement related to supporting biomaterials. The sustainable improvement of AI processes and their supporting biomaterials is purposed to ensure the effectiveness and efficiency of assisted reproductive animal breeding. In order to reach the purpose, particularly, it is a need for researches on the biomaterials supporting AI technology. Our paper reported a systematic literature review results and current laboratory works in that area.

2. MATERIALS AND METHODS

A systematic literature review (SLR) [3] was conducted to provide an accurate and comprehensive unbiased synthesis of relevant searched literatures regarding biomaterials supporting processes of artificial insemination technology.

We searched electronic databases using search engines, namely Google Scholar, Research Gate, Garuda, and Scopus for gathering the published last decade (2017-2021) articles (research paper, review, thesis, dissertation and conference proceeding as well as patents) in September 2021. We adopted the PICOS [4] (P = problem, I = intervention or solution, C =

comparators, O = outcomes, S = study type) format for formulating research questions focusing on materials and processes involving the steps in performing artificial insemination technology for husbandry animal reproduction. The search was performed with keywords combined with Boolean operators AND, OR, and NOT.

There were totally 18,000 publications retrieved from the databases by using key words artificial insemination. From the large numbers of publications regarding artificial insemination, we focused screening on combination keywords namely artificial insemination technology (n=437), artificial insemination materials (n=32), biomaterials AND artificial insemination (n=341), biomaterials AND artificial insemination technology (n=5), and inorganic biomaterials AND artificial insemination technology (n=1). Thus total 816 publications were retrieved using those keywords.

Data related to the study question were extracted and combined with our current research. Data were analysed and synthesized narratively.

3. RESULTS AND DISCUSSION

After assessing the quality of publications through matching PICOS criteria and risk of bias, we finally selected 65 full papers to further study, as depicted in Table 1.

The 65 selected full papers were matched to criteria through spreading them to the steps of processes and biomaterials used for supporting those steps of artificial insemination processes of ruminant animals. For instance, artificial insemination process of cows [5] that can be described as a flow diagram as detailed on Table 2. The AI processes include animal fertility assessment, semen collection, semen evaluation, semen processing, spermatozoa preservation, and insemination [5]. Those AI steps need supporting biomaterials as well as apparatus/techniques.

Cryopreservation of semen/spermatozoa as the important part of artificial insemination has advantages dan disadvantages as shown in Figure 1.

The advancement of artificial insemination technology in terms of methods/techniques/apparatus and supporting biomaterials reviewed systematically by using literatures since last 5 years. There is a need to develop novel biomaterials as novel procedures to enhance the quality of preserved spermatozoa and

Table 1. Retrieved and Criteria Met Publication

Search keywords	Publication Numbers	Criteria met
"Artificial insemination technology"	437	98
"Artificial insemination materials"	32	16
"Biomaterials" AND "artificial insemination"	341	88
"Biomaterials" AND "artificial insemination technology"	5	3
"Inorganic biomaterials" AND "artificial insemination"	1	1
Total relevant publications after removing duplicates		191
Selected full papers related to artificial insemination materials and process in animal husbandry		65

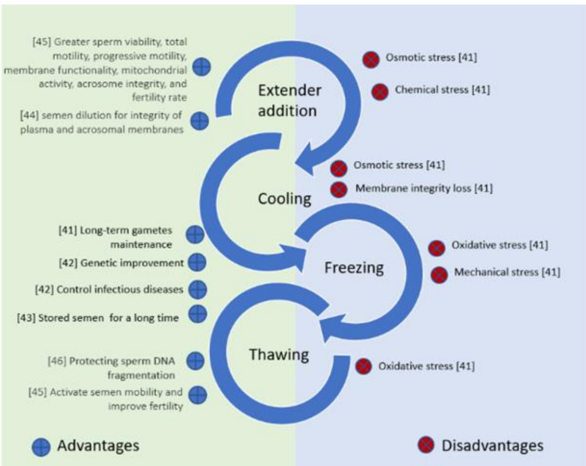

Figure 1. Advantages and Disadvantages of the Cryopreservation Steps.

Table 2. Steps of AI Processes and Supporting Biomaterials Needed

Steps of AI Processes	Apparatus/Technique/Methods	Supporting Biomaterials
Animal fertility assessment	A sensor based automatic ovulation prediction system [6]; excessive negative energy balance (eNEB) [7], Genomic data [8]; Cow fied data set [9].	enzyme linked immunoassay (ELISA)[6]; high-density single-nucleotide polymorphism chip assay [8]
Semen collection	Electroejaculation and transrectal massage method [10] {16] [17]; Artificial vagina equipped with a scaled glass tube [11], collector tube inside the artificial vagina [12]	NaCl 0,6% [12]
Semen evaluation	0,25 mL straws and were sealed thermally [13]. CASA Analysis [18][19]; flow cytometric analysis [19]; enzyme GOT-GPT leakage pre- and post-freezing [20]	PVA powder [13]; TFYG diluent [20]
Semen processing	Fresh diluted, Equilibration, 0h Post-thaw, 1h Post-thaw [14]; elimination of semen viscosity [22]; enzymatic and mechanical liquefaction of seminal plasma on freezability of semen [23]	tris egg yolk extender [14] [18], nano-copper and nano-zinc particles during in vitro maturation [15]; DMSA-coated maghemite nanoparticles [21], nanoparticle [24]; vitamin [25]
Spermatozoa preservation	distinct freezing curves after thawing [26]; exposure to CeO_2 nanoparticles during storage at 4 C for 96 hours [27]; Cryopreserve in liquid nitrogen [18] [28][29] [30] (31][32][33] [34]	CeO_2 nanoparticles [27]; plastic straws [28][29][30][31][32] [33]; antioxidants reduce lipid peroxidation and improve quality of crossbred ram sperm [34]; carboxylated Poly-l-lysine and glycerol on freezability [35]; Tris Extender Supplemented with Ethylene Diamine Tetraacetic Acid [36]
Insemination	Timed Artificial Insemination Following Oestrous Synchronization [37]; Gedis® Systems [39]; Three-Dimensional (3D) Porcine Preantral Follicles Culture Utilizing Hydrophobic Microbioreactors [40]	NaCl to maintain of viability and motility of spermatozoa [38]

reduce costs as well as an appropriately fit technology for husbandry. For instance, it was reported that the AI for animal husbandry still has problems, especially its effectiveness [41]. Our current works, as purposed in the brief reviews [47] [48], are developing biomaterial supporting artificial insemination based on local raw materials. For instance, the silica biomaterials were originated from rush husk and phosphates of hydroxyapatite from animal bones wastes. Those biomaterials were used to produce a straw having properties of humidity and temperature sensor in the form of silica gel beds in order to develop a novel ambient temperature spermatozoa preservation as well as novel formula of extender for enhancing the quality of semen.

4. CONCLUSION

The current development of AI for animal husbandry has an important role in enhancing productivity, improving the sustainability of food security as well as improving genetic conservation. However, it has still a lack in effectiveness and cost because of cryopreservation needs freezing step using liquid nitrogen. We proposed that developing better techniques and biomaterials supporting AI could be not only low cost but also eco-friendly, which might contribute to the sustainable development of food for all people leading to the human beings as well as animal welfare.

For small tables, please place it within a column and bigger table be placed in a text frame spanning to both columns. Use the Table facility available within the MSWord. The font in the row header should be bold and you can use the style available from the style palette.

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