A brief review on advanced renewable materials for supporting artificial insemination technology

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Abstract. This paper is a review paper. National meat self-sufficiency program (MSSP), which has been launched since 2000, has been well improved in term of concept, policy instrument, and program management, but the supporting technologies are still as one of some constraints. The study was aimed to metaanalyze comprehensively the frontier technologies supporting the national MSSP, especially advanced materials for artificial insemination technology in order to enhance animal population. The meta-analysis study adopted Wilson and Kelly metanalisis methods consisting of nine steps. Results of the study showed that (1) there were some frontier advanced technologies on animal husbandry in terms of breeding, fattening up and farm management, as well as animal feeds and feedstock’s; (2) those technologies consisted of advancing materials dan methods/process; and (3) particularly, in supporting breeding technology, advancing artificial insemination technologies take important role for significantly enhancing the animal population as well as effectiveness of animal breeding, thus advancing the materials as well as processes involved are highly needed. The study concluded that advanced renewable materials for supporting artificial insemination technology should be taken into account for advancement of animal husbandry technology.

1. Introduction

Meat self-sufficiency has been become greater attention since last two decades in Indonesia, thus a national meat self-sufficiency program (MSSP) was launched in year 2000 because of trend of higher meat consumption but lack of animal husbandarily production of meats. Rich in natural resources, as a country having huge tropical rain forests and large numbers of biodiversity, does not mean that Indonesia can supply meats in enough quantity, quality dan continuity for well matching with the meat demand. Indonesia itself in a four year duration 2015–2018, for instance, imported meat in amount of 669,918.80 tonnes [1].

Nowadays, the National MSSP has been going forward with a lot of progress in term of concept, policy instrument, and program management. However, the supporting technologies for the MSSP are still as one of some constraints. Meanwhile, meat consumption per capita globally is predicted increase significantly in one decade (2015-2025) from 35.3 kgs r.w.e (retail weight equivalent) to 36.6 kgs r.w.e. [2]. Advancement of the animal husbandary technologies is believed to be taken an important role, especially materials for artificial insemination technology in order to enhance animal population. Although some literature reviews on artificial insemination (AI) to improve farm animals reproduction and genetics were already conducted by researchers [3,4], however a comprehensive meta-analysis study on AI technology for animal husbandary, especially on advanced materials for AI is still rarely
done previously. The study was aimed to metaanalyze comprehensively the frontier technologies supporting the national MSSP, especially advanced materials for artificial insemination technology in order to enhance animal population.

2. Methods
This report was resulted by a comprehensive meta-analysis study adopting Wilson and Kelly method which could be found elsewhere [5]. The meta-analysis study involved nine steps, namely (1) determining topics and area of study, i.e. animal husbandry in general for meet self-sufficiency program, especially frontier material technologies supporting the animal husbandry, and frontier advanced materials for artificial insemination for supporting breeding technology; (2) determining time period of research results that were used as information or data resources, i.e. two one decades (2000–2020); (3) researching and collecting published international articles supporting the determined topics; (4) looking through the titles and abstracts of those selected articles as the study population or samples; (5) focusing the meta-analysis study on (a) advancement technologies on animal husbandry in general, and (b) advancement technologies on artificial insemination; (6) categorizing each research article into the chosen theme or issue; (7) comparing all results of the researches according to its category; (8) analyzing conclusion, and (9) concluding the meta-analysis study.

3. Results and discussion
Firstly, the meta-analysis study was successfully determined the selected general topics of animal husbandry technology in order to reach the national goals of MSSP was breeding technology to significantly improve the national farm animal population. The main foundation of the breeding technology could depend on the advancement of biomaterials, moreover the artificial insemination as a core of breeding technology depends tightly also on the advancement of the related biomaterials. Fabulous numbers of international articles on those topics were published last two decades (2000-2020).

Secondly, the meta-analysis study was also determined the focus around the scope of advancement technologies on animal husbandry in general and new-age technologies on artificial insemination in particular through analyzing of all abstracts of the population articles as depicted on Table 1 dan Table 2 respectively.

| Nr. | Content maps                                      | References       |
|-----|---------------------------------------------------|------------------|
| 1   | Breeding                                          |                  |
|     | a. Housing system and management                  | [6,7]            |
|     | b. Advanced technology and materials of breeding  | [8-20]           |
| 2   | Fattening up and farming management               | [21-24]          |
| 3   | Feeds and feedstocks                              | [25-31]          |

Table 1. Scope maps of advancement technologies on animal husbandry.

Table 2. Scope maps of advanced technologies on artificial insemination.

| Nr. | Content maps     | References            |
|-----|------------------|-----------------------|
| 1   | Advanced materials used | [12,13,18]           |
| 2   | Advanced technologies | [8-11,14,19-20]      |

Thirdly, a comparison among results of researches of the focussed categories was conducted. The focussed categories are breeding technology consisting of housing system and management, as well as the advancement of breeding technology and materials used, followed by fattening up and farming management, feeds and feedstocks and added values of main products, by products and wastes. comparing all results of the researches according to its category. Furthermore, a discussion on particular advanced technologies on artificial insemination and materials used is taken into account.
One of the most important components in the animal production farms is animal breeding, that it is not only enhance animal population but also improve the animal genetics. The technology as well as materials advancement takes essential role. Some of technologies and materials used are compared here [8-20] insteads of the housing system and breeding management [6-7]. One of the wellknown new age technologies in animal farming [14] is artificial insemination, i.e a simple and low cost human helped animal reproduction process of insemination [8] as it is very preliminary technical modernization in animal reproduction [17], that is now common practicized in all types of farm animals such as sheep, goat, cattle, buffalo and swine. Recently, for improving quantity as well as quality of the animal production, hormonal treatments, especially an estrous synchronization with exogenous hormone [9-11], become a great attention and more practicized today, for instance the hormonal treatment could produce superior bull, uniform calf, and reduce breeding season duration [10]. The hormonal treatment nowadays becomes more convinient since the side effect of external animal stress could be controlled, for instance by using low-level progesterone coding in the estrous synchronization with controlled internal drug release device, that is very suitable applied with no residual side effect for farming animals such as swine, sheep and goat [12], moreover, the hormonal treatment technology was advanced by a treatment of using a male transplanted from spermatogonial stem cells of donor males in order to produce large numbers of progeny within the same time [13] and DNA marker for calculating the breeding values of animals [18]. Because of very dynamic in assessing of the animal genotypes in those smart animal farming technologies, an innovative technique to evaluate animal morphology and their health status is needed for example 3D-Bull model of the structure from motion (SfM) algorithm and contrast-enhanced ultrasound (CEUS) [15,16]. Those advanced artificial insemination technology and related smart breeding technologies enable us to enhance the accuracy of selecting beneficial animal genes for better milk production, more disease resistance and higher fertility. The advancements of smart breeding technology with advanced artificial insemination, however, the supporting materials used for preserving animal category and fighting against new health disasters need to be improved. The freezing of old genetic germplasm of the animals by storing in an artificial insemination straw and in liquid nitrogen seems not only timely bound by preserving liquid nitrogen where in some cases the liquid nitrogen is not cheap and sometimes difficult to obtained continously. These key technologies such as fixed-time artificial insemination, auto-weighing, heat detection, biomarker, electronic identification, robotic milking, controlled feeding, health monitoring, and disease diagnosis sensors [12], need to be supported by advancement of materials used, as well as the AI apparatus [19,20], need to be improved for more suitable with those smart technologies.

Further respective development of science and technology of animal farming after breeding is the advancement in animal fattening dan farming management. Both advancement is highly correlated leading to efficiency and productivity of meet production, for instance in a cattle fattening farm, positive relationships were found between economic efficiency and feeding frequency, the ratio of Holsteins in the herd, fattening period, existence of a management record, contacts with extension services and credit use [21]. The economic performance of fattening farm can be quantified by using the net farm income and labor productivity, in the other hand the environmental performance of fattening farm can be quantified with a life cycle assessment for land occupation, non-renewable energy use, global warming potential, eutrophication potential and acidification potential [22]. Recently, fattening farm can be managed by using algorithms leads to smart farming [23], where the smart farming technology works by using hardware and software, thus the farmers can manage their works using the robotic machine [24].

Feed and feedstocks are also essential for animal farming, thus advancement of the science and technology supporting the quantity, quality, quantity and continuity of preserving animal feed takes important rule. For instants, a beef herd submodel was already purposed by formulating feed diets to meet protein, energy, and mineral requirements with available feeds, then the herd submodel was verified to perdict feed intakes, nutrient requirements, diets and manure excretions [25]. Increasing the supply of sustainable protein is also valuable in animal farming feed. Instead of soybean and other protein rich plant biomasses as well as fishmeal, the use of insect protein provides a potential alternative,
for instance the larvae of house fly (Musca domestica), blue bottle (Calliphora vomitoria), blow fly (Chrysomya spp.) and black soldier fly (Hermetia illucens) [26]. A further research investigated that the nutritional quality of insect meal protein of black soldier fly larvae, the house fly maggots, mealworm, locusts–grasshoppers–crickets, and silkworm could offer crude protein contents about 42–63% and lipid contents up to 36% oil, but they were still lack calcium and fatty acids contents (those can be enhanced by suplementation), thus they can be prospectively developed as animal feed in large scale [27]. On the other hand, microalgal biomasses such as Chlorella sp., Scenedesmus sp., Desmodesmus sp., Chlamydomonas sp., Pseudomuriella sp., Tetraedron caudatum, Graesiella emersonii, and Mychonastes timauensis because of their rich protein contents could be prospectively used for animal [28]. Those biomasses need a pretreatment in order to lower the recalcitrance, and more susceptible to enzymatic digests by farming animals [29]. The other technique for enhancing the nutrition quality as well as improving enzymatic digestion, feedstocks biomasses, for instances high dry matter switchgrass and reed canarygrass were anaerobically stored in farm-scale silo bags with aerobic exposure of a combination of homofermentative (Pediococcus pentosaceus) and heterofermentative (Lactobacillus buchneri) bacterium in order to increase the production of both lactic and acetic acid during storage [30]. Furthermore, the uses of enzymes in animal feed industry as additives, for examples xylanases and β-glucanases, can improve the performance in animal farming [31]. Thus, the advancement of treatment technoloy of biomass feedstocks is taken also important rule in order to provide better animal feeds.

Fourthly, before drawing a conclusion of the meta-analysis there are some points coming into consideration namely (1) there were some frontier advanced technologies on animal husbandry in terms of breeding, fattening up and farm management, as well as animal feeds and feedstock’s; (2) those technologies consisted of advancing materials dan methods/process; and (3) particularly, in supporting breeding technology, advancing artificial insemination technologies take important role for significantly enhancing the animal population as well as effectiveness of animal breeding, thus advancing the materials as well as processes involved are highly needed.

4. Conclusion
It can be concluded that advanced renewable materials for supporting artificial insemination technology should be taken into account for advancement of animal husbandry technology.

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