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研究課題名(和文) モンゴルの伝統食「馬乳酒」製造に関する伝統的知識の科学的検証と応用

研究課題名(英文) Integration of Traditional and Scientific Knowledge for Promoting Fermented Horse Milk Production

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研究成果の概要(和文)：馬乳酒はモンゴルの伝統的で代表的な乳製品であり、モンゴル国内外で健康的な食品へ関心と馬乳酒の需要が増加しているため、高品質の馬乳酒を生産する伝統的知識の記録と、要因の解明が重要である。国全体で聞き取り調査をおこなった結果、馬乳酒生産は中央部および南部、西部で盛んであった。高品質の馬乳酒生産に重要だと多くの牧民に認識されている項目は、牧民の技術、酵母の選択、植物の種類であった。馬乳酒生産用のウマの行動圏は、搾乳時間帯(日中)より非搾乳時間帯(夜間)で大きかった。これは水場や塩類露出地域、食物の利用可能量の空間分布が影響したと考えられ、放牧地の選択とウマの管理手法の重要性が示唆された。

研究成果の概要(英文)：Airag (fermented horse milk) is a traditional and most representative milk product in Mongolia and interests in healthier foods and demands of airag have been increasing within and beyond Mongolia. Therefore, recording the traditional knowledge and analysis of factors to make high-quality airag are important. Nationwide survey demonstrated that airag production was intensive in central, southern and western Mongolia. Important factors recognized by herders to produce high-quality airag were herders' skill, selecting good yeast, and plant species. Ranges of horses for airag production in a famous area for high-quality airag were larger during non-milking period (nighttime) than milking period (daytime). It would reflect spatial distributions of water, salt, and forage availability. Importance of site selection and horse managements for high-quality airag production was suggested.

研究分野：agrometeorology

キーワード：fermented horse milk nomads traditional knowledge GPS observation drylands

1. Background

(1) Pastoral nomadic animal husbandry is a major industry in Mongolia; it has been sustained for thousands of years under the severe cold and dry climate through an elaborate system that includes seasonal movements and selection of camping locations, herding techniques, grassland management, food production and mitigation of the effects of natural disasters. Mongolia has reason to be concerned about climate change; increasing frequency of extreme events such as drought and *dzud* (severe weather) during the past decades. Such impacts have led to more threats in the farming of livestock and pasturing, which has been already vulnerable. Moreover, abrupt changes of socio-economy in Mongolia, greatly affected on livestock breeding and tradition. With these facts, it is needed to introduce an elaborated traditional knowledge with an integration of scientific achievements to sustain the livestock industry and alleviate the possible impacts of climate change.

Over the last decade, traditions related to non-cow milk and fermented food have been the subject of increased global attention because: (1) they carry cultural significance that needs to be preserved as these practices are in danger of dying out; (2) they are derived from traditional agriculture and have little environmental impact as they do not require great resource infrastructure; (3) the products themselves have high nutritional value; and (4) the production of these items can promote local economic growth if hygiene and transportation problems are solved.

Airag (fermented horse milk) has been produced in Mongolian households for thousands of years. It is a mildly alcoholic (a few percent), sour drink usually made from fresh horse milk. *Airag* is rich in fermenting agents (lactic-acid bacteria and yeast), trace elements, antibiotics, vitamins A, B1, B2, B12, C, D and E, ethyl alcohol, lactic acid and carbonic acid. Because of its abundant nutrients, some Mongolian herders drink *airag* instead of having proper meals during summer. Although *airag* forms such an important component of traditional Mongolian food, very few studies have been conducted on it. In addition, the way of nomadic life has been changing rapidly; the traditional production of *airag* has been decreasing and can now be found only in limited parts of Mongolia. For better *airag* production, it is therefore important to examine and record how traditional *airag* is made.

(2) *Airag* is intensively produced and consumed in central, western, and southern Mongolia (Bat-Oyun et al., 2015). Its quality (i.e., taste) differs among regions and even among households because of the variety of herders' skills: in producing yeast and *airag* and in selecting containers, forage plant species and productivity, weather, and accessibility of water and minerals (Bat-Oyun et al., 2015). As the urbanization is intensified in Mongolia, demand for high-quality *airag* is strong and expected to increase. It is therefore important to know the methods and the environmental conditions to make better quality *airag* with sustainable grassland use.

(3) The growing interest in healthier foods has increased demand for *airag*, which is both a non-cow dairy product and a fermented food, within and beyond Mongolia. However, as the way of nomadic life has been changing rapidly, the traditional production of *airag* has been decreasing and can now be found only in limited parts of Mongolia. It is therefore important to examine and record how traditional *airag* is made.

2. Research objectives

(1) To identify the regional distribution of activity level of *airag* production throughout Mongolia.

(2) To explore the environmental and human-related factors that controlling quantity of *airag* production.

(3) To identify determining factors for quality of *airag* production.

(4) To evaluate the effects of horse management on movement of mother horses in an area famous for producing high-quality *airag*.

3. Materials and methods

(1) A first nationwide questionnaire survey on *airag* production was conducted through the Mongolian meteorological network, targeting 2045 herders. The incidence of *airag* production was determined on a county scale, using the ratio of herding households that produce *airag* to the total number of households. This activity was then ranked into four regional levels: almost no production (Region I), a low level (Region II), a medium level (Region III) and a high level (Region IV). The regional level corresponded to answers to the questionnaire item 'Do herders in your county make *airag*?' The possible answers were 'almost none do', 'a few of them do', 'some of them do' and 'most of them do' (Fig. 1).

(2) We tracked three mother horses in a herd in Camp 1 during summer and Camp 2 during autumn of 2013 and analyzed their movements during the milking (daytime) and non-milking periods (nighttime) in Mogod County, Bulgan Province, which famous for its high-quality *airag*. Data was divided into milking and non-milking periods. The milking period in a day is duration from gathering horse herd in the morning in a milking place near herders' house where child horses are separated from their mothers and are tied to the rope for milking their mothers to the last milking in the evening, when child horses are released from the rope. In the same period, mother horses can graze freely on the grasslands except when they are gathered every couple of hours by the herders for milking. The non-milking period corresponds that duration from the release of child horses after last milking in a given day to gathering horse herd in the milking place in next day. Therefore, during non-milking period the mother horses graze freely with their foals.

4. Research outputs

(1) Of the 329 counties, 47 per cent were identified as active (Regions III and IV), while 53 per cent were inactive (Regions I and II). In general, *airag* is not produced evenly throughout Mongolia. Production is intensive in central Mongolia (Khalkh Mongolians), with less activity in the surrounding areas, except for the country's western edge (Kazakh Mongolians) (Fig. 1).

(2) The higher horse density in the north, compared with the south, and the centre of this population distribution is in the central and eastern parts of the northern half, where vegetation patterns are primarily steppe and forest-steppe. High horse and mother horse densities coincide closely with high *airag* production in central Mongolia. Although the eastern regions have large horse and mother horse populations, they have less active *airag* production. Some areas

show a combination of low horse density (high mother horse density) and high *airag* production (Regions III and IV) in the desert and desert-steppe regions and in the western mountains. This implies that a high percentage of mother horses, despite a lower overall horse-density, support *airag* production. A reasonable combination of relatively few horses and low production activity (Regions I and II) is observed in the some desert areas.

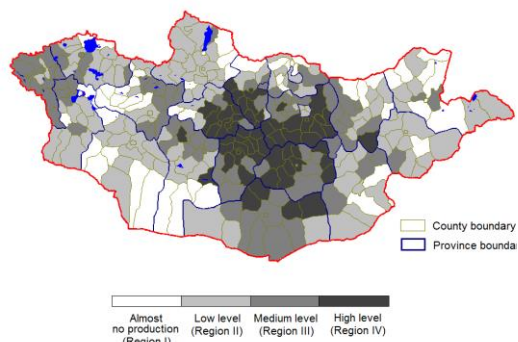


Fig. 1. Quantity of *airag* production (county scale)

(3) *Airag* production began at some point during May–September (mainly in July) for all four regions (51.9–62.8%), while it ended during July–November (although a few cases ended in December): the end was mainly in August and September for Region I, in September and October for Regions II and III, and in October for Region IV). Generally, the time at which production ends lags by approximately one month from Region I to Region IV, and this lag corresponds to the level of production activity. Mother horses are milked every two hours (in a few cases, every hour to an hour and a half), from five to seven times a day during the summer in all the regions. In Regions III and IV, milking occurs six to seven times daily, and in Regions I and II, five to seven times. This implies that herders in areas of more active production milk more often.

(4) Herders in Region I, where almost no households made *airag*, responded to questionnaire items on factors limiting *airag* production as follows: for northern, western and eastern areas, the three most common reasons for not producing *airag* are: lack of experience, lack of labour and less water availability. In contrast, in some desert and desert-steppe regions, herders do not make *airag* due to hot weather, less water availability and insufficient grass. Conversely, the *airag* production level in the some southern region was higher than we expected. Because of the dry climate and low horse-density, it was assumed that production would be low. The higher level of production implies the herders have knowledge of methods for producing *airag* which can overcome these eco-climatological limitations. Lack of production in eastern areas with high horse-density most likely explained by the region produces racehorses, and thus the horse' milk and the herders' labour are primarily directed towards raising foals.

Airag production involves a considerable amount of time and labour in the milking and stirring stages, requiring a sufficient number of herders and temporary workers. In addition, answers to the open-ended question regarding reasons for not making *airag* included 'no tradition' of *airag* production in here. In brief, factors other than eco-climatological conditions, human-related factors such as labour, pastoralists' cultural background and ethnicity might account for regional distribution of quantity of *airag* production.

(5) The factors recognized by herders were plant species, salt mineral and weather in a pre-production phase; skill, yeast, choice of containers, fermentation temperature and hygiene in a main production. Yeast plays a vital role in *airag*'s quality, and the first fermentation requires specific experience and skills. Nevertheless, the number of people in Mongolia who can make good yeast is decreasing.

Many herders said that *airag* made in *huhuur* (traditional container, made by cattle skin) tastes better than that made in other containers. The number of herders who use *huhuur*, however, has decreased over the last few decades instead; many have begun using plastic containers for convenience's sake.

Herders used various types of containers for fermenting *airag*, such as plastic containers (59.8%), *huhuur* (23.8%), wooden buckets (8.6 per cent), aluminium-ware (4.4%), iron-ware (1.4%) and other materials (2%). Our survey conducted over 60 herder families in a famous *airag*-producing region in Mongolia indicated that some efforts have been undertaken to encourage the use of traditional tools and equipment, and these have led herders to use *huhuur* once again, especially in the famous *airag*-making regions, such as Saikhan and Mogod counties in Bulgan province.

In addition, many herders in this region considering that plant species in their area are most important factor for high-quality of *airag*. Moreover, salt-mineral deposit and fresh water are included as factors for *airag* quality. Regarding fermentation temperature, according to our questionnaire survey lower temperatures are not suitable, while higher temperatures can result in a sour product. However, we did not receive an answer regarding the optimum temperature range.

(6) Mother horses were gathered every 1.7 ± 0.0 h between 7:46 am and 15:47 pm at the milking sites and milked 4.6 ± 0.2 times/day during the study period (86 days). Daily cumulative and maximum linear distances from the milking sites were longer ($p < 0.01$) during the non-milking period than during the milking period. Daily home ranges were 91 and 26 times greater during the non-milking period ($p < 0.001$) in Camps 1 and 2, respectively (Fig. 2). The mother horses seemed to move together. The greater range during the non-milking period would reflect the spatial distributions of water, salt, and forage. The mother horses visited the river every day during the non-milking period except for one day at the beginning of Camp 1.

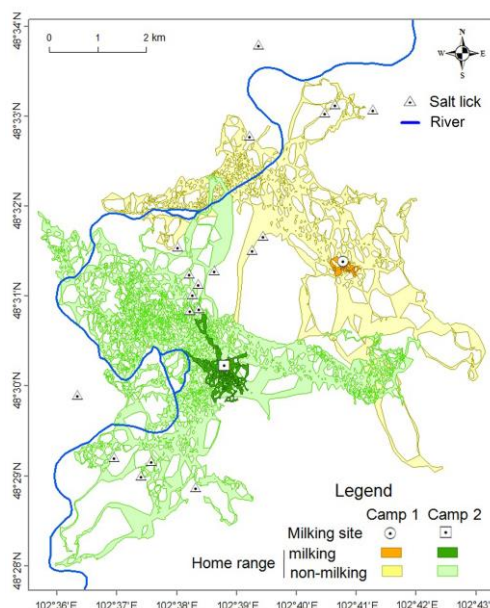


Fig. 2. Home ranges of a mother horse (with complete data) during milking and non-milking periods in the Camps 1 and 2.

(7) First study focused on collecting the data nationwide, and a semi-quantitative and subjective index was used to determine the activity level of *airag* production and collect traditional herders' knowledge on determining quality and quantity of *airag* production. The production was intensive only in limited parts of Mongolia. From this study focus on a specific region to obtain more quantitative observations including meteorological elements, pasture conditions, soil nutrition, water quality and GPS tracking of herds was suggested for efficient *airag* production. Therefore, in the next step we studied the movements of mother horses managed for *airag* production selecting famous *airag*-producing region. Results showed that the greater range during the non-milking period reflected the spatial distributions of water, salt, and forage. The horses initially used similar areas and gradually shifted their daily home ranges after several days. This shift suggested that the mother horses grazed farther afield as forage availability declined around the milking site. For better *airag* production and sustainable pasture use, milking management for selecting suitable sites and choosing the right timing to shift milking sites and appropriate milking times and frequency would be important. In future, more quantitative observation and experiment on examining effects of vegetation type and biomass, fermentation temperature and container on *airag* quality and quantity would add understanding to the elaborate abilities required for high-quality *airag* production. Moreover, integrating traditional procedure of *airag* preparation and scientific results, a detailed *airag* preparation manual on the procedure of *airag* preparation, season of *airag*, appropriate vegetation and optimum temperature conditions to produce high quality of *airag*, and the best selection of yeast and container should be prepared for efficient *airag* production and sustainable environment use. As improved *airag* production, this will lead to a promotion of local economy, elaboration and sustainability of livestock industry.

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6. Research organization

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