IAC-23- E5.IP.17

The Possibility of Developing Japanese Culture through "NATTO" in Space

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Abstract

In Japan, there is a food called "Natto" (fermented soybeans). Natto is made from fermented soybeans and has a distinctive smell and consistency that divides the likes and dislikes among Japanese people. It is highly nutritious and can be preserved better than fresh food that can be eaten without processing. In the past, Natto that had been made by taking the Natto bacillus to the International Space Station has been sold in the market back on Earth. However, Natto has not yet been certified as a space food by NASA or JAXA. Is it possible to make and eat Natto in space? In this paper, we discuss Natto as one of the Japanese food cultures and the possibility to expand the food culture in space.

Keywords: Space Travel, Space Food, Natto, Fermentation, Culture,

1. Introduction

I like natto. Natto is a food made from fermented soybeans. Since it is a fermented food, it is good for the body. If I were to choose what my last supper would be, I would choose "natto tamagokakegohan," which is natto mixed with a raw egg and a little soy sauce all mixed and served over warm cooked rice. Since natto has not yet been certified as a space food, I wanted to make natto available in space before I go there.

Fig.1. Natto and rice with egg

Natto is considered one of the symbols of Japanese food culture because it is not often eaten outside of Japan. To discuss natto would be to focus on fermented foods in Japanese food culture. Natto has a strong smell, so it is necessary to be a little creative to eat it in outer space, where people from different cultures gather from all over the world.

Fig.2. Natto

It is also characterized by its stringiness. These strings are difficult to break even when stretched, so care must be taken when eating natto.

2. History of Natto

There are various theories about the origin of natto. The two most popular theories are that natto originated in Japan during the Jomon period (approximately 13,000 to 2300 years ago) and the Heian period (approximately 940 years ago). In both theories, boiled soybeans were stuffed into straw, which fermented, causing the soybeans to string and give off a unique aroma. It is believed that since the Edo period (about

500 to 300 years ago), it has been a favorite item on the morning table of many households in Japan.

Fig.3. Natto wrapped in straw

Although Japanese people have different likes and dislikes, it is an easy and familiar food that has existed for 3-5 centuries, mainly as a breakfast menu.

3. Japanese fermented food culture

First, fermentation and putrefaction are both phenomena in which proteins and carbohydrates are broken down by the action of microorganisms and enzymes. It is said that the only difference between fermentation and putrefaction is "whether or not it is useful to humans. There are many fermented foods in the world, but there are so many fermented foods in Japan that it can be said that Japanese food, including miso and soy sauce, is supported by these fermented foods. Natto (fermented soybeans) is also produced by a microorganism called "Bacillus natto," which is responsible for the fermentation process.

Fig.4. Japanese Fermented Food

4. Problems for eating natto in space

In the early 1990s, Japanese astronaut Mamoru Mohri applied to eat natto in space, but the application was denied because of two major characteristics: the strong odor and the stringiness, the stringiness of which is likely to affect precision machinery on the spacecraft. Since then, it has not been approved as a space food. Probably, no application has been filed since then.

On the other hand, if natto is to be made in space, it is necessary to take a microorganism called "Bacillus natto" to space. So far, the natto that was allowed to stay and ferment on the International Space Station sold on Earth, so it is still possible to carry the "Bacillus natto" itself to space. However, "Bacillus natto" has a very strong reproductive capacity, so strong that it is said that when visiting other fermented food factories in Japan, one should not eat natto for breakfast. This is because the Bacillus subtilis natto is so strong that it interferes with the fermentation process of other yeasts. Furthermore, although it has not been tested yet, it is also believed that it can live in outer space outside a spaceship. [92]

5. Cause of Natto Stringiness

Natto's stringiness is caused by an amino acid called glutamic acid and a carbohydrate called fractan, which are among the various substances produced when the bacillus natto breaks down the protein contained in the soybeans. Glutamic acid is a kind of umami ingredient that makes natto tasty and forms fine threads at the same time. And fractan has the function of stabilizing the sticky threads.

Fig.5. Natto threads

Natto and sticky threads are inseparable, but if natto is left as it is, the threads become harder to pull. This is because as the natto bacteria increase and become overcrowded, they produce enzymes that break down the glutamic acid, which is also a component of the strings, as nourishment. Just because it is less likely to pull strings does not mean that the number of strings will be reduced to zero. However, using well aged natto for natto to be taken to space can be one idea to avoid natto strings. [93,94]

6. Solution

GENKI LABO, a Japanese organization, tested what happens when natto is placed on cooked rice and freeze-dried by pouring liquid nitrogen over it and then freeze-drying it for one day.[96] The natto portion of the freeze-dried natto rice was not stringy, did not smell too strong, and met the criteria for space food. Both the natto and rice looked white, dry, and tasteless, but when they tried it, contrary to their expectations, they found that it tasted exactly like natto rice. Incidentally, freeze-dried natto rice returned in hot water is not tasty and is not recommended.

Thus, freeze-drying is likely to be one solution that can be adopted. Many foods other than natto have already been adopted for space food by freeze-drying and returning them to hot water. In this state, natto will have no smell and will not be stringy, so it is highly possible that natto can be eaten not only in space but also on Earth.

As for making natto inside a spacecraft, it is necessary to verify whether other foods and machines will be affected, but the feasibility of making natto outside a spacecraft in space increases at once.

Incidentally, Mizkan, a Japanese food manufacturer, has discovered a new natto bacterium and produces and sells natto that has neither the odor nor the stringiness characteristic of natto by fermenting it using a proprietary process. With this product, not only does it not have stringiness, but it also does not cause odor problems, which lowers the hurdle for taking natto into space.[95]

Fig.6. “Bi-natto” with no smell or stringiness

And there are several other products, such as "Niowa Natto" and "Mame no Bunshiro," that suppress the unique smell of natto, although it does pull strings. Products that have already been developed on the ground in response to consumer demand have lowered the hurdle to making natto available in space.

Fig.7. Natto with reduced odor

Furthermore, although the International Space Station has strict rules and restrictions set by each country, a commercial spacecraft, especially one that does not even have a cockpit and no switches or equipment on the surface, such as SpaceX's Crew Dragon or Blue Origin's New Shepherd, may have no problem with the current string of natto.

At least, for stratospheric space travel planned by Space Perspective and Worldview Enterprises, which can go to the stratosphere with a balloon, pulling strings will not be a problem, because the spacecraft will not even be weightless.

7. Conclusion (Possibilities to expand food culture in space)

Natto was once applied for space food and rejected by NASA, so it has not been applied for and has not become space food since then. As time goes by, many things will become possible with newly developed technology. With the current technology, it will be possible to take natto to space. If further development makes it possible to eat natto in space while it is still stringy and emits a unique smell as it does when eaten on the ground, this technology will make it possible to eat foods other than natto that have special characteristics in space as well.

ASTRAX will continue to develop and provide food-related services to contribute to the enrichment of life in space.

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IAC-23- E5.IP.17

宇宙空間における納豆を通した日本文化の展開の可能性

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アブストラクト

日本には、「納豆」という食べ物があります。納豆は大豆を発酵させたもので、独特の匂いと粘りがあり、日本人の中でも好き嫌いが分かれます。ただ、栄養価は高く、加工しなくても食べることができ、生鮮食品よりは保存がききます。過去に、納豆を作るために必要な納豆菌を国際宇宙ステーションに持っていき、地上に持ち帰って作られた納豆が、市場に売られています。しかし、NASAやJAXAにおいて、納豆はまだ宇宙食として認定されていません。そもそも、宇宙で納豆を作ったり食べたりする事はできないのでしょうか。本論文では、日本の食文化の１つとして、納豆をとりあげ、宇宙での食文化を広げるための可能性について考察します。

キーワード：宇宙旅行、宇宙食、納豆、発酵、文化

1. イントロダクション

私は納豆が好きです。納豆とは、大豆を発酵させて作られた食べ物です。発酵食品なので体にもよく、私は最期の晩餐は納豆と生卵、少しの醤油を全て混ぜて温かい炊き立てのご飯にかけて食べる「納豆卵かけご飯」がいいと思っています。そんな納豆がまだ宇宙食として認定されていないので、私が宇宙に行くまでに納豆を宇宙で食べられるようにしておきたい、そう思ってこの論文に取り掛かりました。

図1. 卵かけ納豆ご飯

納豆は、日本以外ではあまり食されないため日本の食文化を象徴する1つと考えられます。そして納豆を論ずるということは、日本の食文化の中でも発酵食品にフォーカスすることになるでしょう。納豆は匂いもきついため、各地から異文化の人々が集まる宇宙空間で食すには少し工夫が必要だと考えています。

図2. 納豆

納豆の匂いが苦手な人は日本人でも多いです。日本人以外は初めてその匂いを嗅ぐと食べ物ではない、と思ってしまう人も多くいます。また、

納豆はネバネバした糸を引くのも特徴です。その糸は伸ばしてもなかなか切れないので、この点も食べる時に注意が必要になります。

2. 納豆の歴史

納豆の始まりは諸説あります。その中でも縄文時代（約13000~2300年前）から、というものと平安時代（約940年前）から、というものが有力です。いずれも藁に、煮た大豆を詰めておいたところ、中の大豆が発酵して糸を引き、独特の香りがしてきたため、食べてみたところおいしかったところから広まっていった、というものです。江戸時代（約500～300年前）からは多くの家庭の日本の朝の食卓のメニューとして好まれていたと考えられています。

図3. 藁に包まれた納豆

日本人にとっては3~5世紀もの間、主に朝食のメニューとして存在している手軽で身近な食品であることが分かります。

3. 日本の発酵食品文化

まず発酵と腐敗は、いずれも微生物や酵素の働きによってタンパク質や炭水化物が分解していく現象です。発酵と腐敗の違いは、「人間にとって有用なものかどうか」のみだと言われています。世界中にもたくさんの発酵食品が存在しますが、日本の食事である和食は、味噌や醤油なども含めてこの発酵食品に支えられていると言えるくらい、日本には多くの発酵食品が存在します。納豆も「納豆菌」という微生物が発酵の働きをして納豆を作り出しています。

図4. 日本の発酵食

4. 宇宙で納豆を食べるための問題点

1990年代前半に日本の宇宙飛行士の毛利衛氏が納豆を宇宙で食べたいと申請をしましたが、臭いがきついというのと糸を引くことの２大特徴のうち、糸を引く点が宇宙船にある精密機械に影響を及ぼす可能性が高いとして、認められませんでした。それ以降、宇宙食に認定されていません。おそらく、その以降現在まで申請もされていないと考えられます。

一方、宇宙で納豆を作るとすると「納豆菌」という微生物を持って行く必要があります。これまでに、国際宇宙ステーションに滞在させた「納豆菌」を地球に持ち帰り、地球でその「納豆菌」を使って大豆を発酵させて作った納豆が販売されているので、「納豆菌」自体を宇宙に運ぶことは現在でも可能です。ただ、「納豆菌」は繁殖力がとても強く、その強さは、日本で他の発酵食品工場に行く際は朝食に納豆を食べてこないこと、と言われるほどです。「納豆菌」が強すぎて、他の酵母菌の発酵の働きを妨げてしまうからです。さらに、まだ実験はされていませんが、宇宙船外の宇宙空間でも生きられるとも考えられています。(a)

5. 納豆が糸をひく原因

そもそも納豆が糸を引く原因は、納豆菌が大豆に含まれるタンパク質を分解する際にできるさまざまな物質のうちの「グルタミン酸」というアミノ酸と「フラクタン」という糖質によるものです。グルタミン酸はうま味成分の一種で、納豆を美味しくするのと同時に細い糸を形成し

ます。そして、フラクタンには、そのネバネバの糸を安定させる働きがあります。

図5. 納豆の糸

納豆とネバネバの糸は文字通り切っても切り離せないものですが、納豆をそのまま置いておくと、糸を引きにくくなっていきます。これは、納豆菌が増えて過密状態になってくると、糸の成分であるグルタミン酸も納豆菌が栄養として分解する酵素を出すようになるからです。糸を引きにくくなるだけで、糸がゼロになるわけではありません。ただ、宇宙に持っていく納豆はしっかりと熟成した納豆にすることは、納豆の糸を回避する一つの案になり得ます。[93,94]

6. 解決方法

日本の団体GENKI LABOは、炊いたご飯に納豆を載せて、そこに液体窒素かけて凍結させた後、1日間の凍結乾燥を行ってフリーズドライにするとどうなるかを実験しました。フリーズドライした納豆ご飯の納豆部分は、糸は引いておらず、臭いもきつすぎず、宇宙食の基準を満たしていました。見た目は、納豆もご飯も白く乾燥して美味しくなさそうでしたが、いざ食べてみると予想に反してしっかりと納豆ご飯の味がしたそうです。ちなみに、フリーズドライした納豆ご飯をお湯で戻した場合は、美味しくなく、推奨しないそうです。

このように、フリーズドライは、一つの解決方法として採用できる可能性が高いです。納豆以外の食品でも既にフリーズドライにしてお湯に戻すという方法で宇宙食に採用されているものも多く存在します。

この状態であれば、独特の臭いや糸をひく状態を嫌がって納豆を嫌厭していた人たちも、臭いもなく糸も引かない状態になるので、宇宙だけでなく地球上でも納豆を食べられるようになる可能性が高いです。

宇宙船内で納豆を作ることに関しては、他の食品や機械に影響がないかを検証する必要がありますが、宇宙船外の宇宙空間で作ることを視野に入れると一気に実現可能性が高まります。ちなみに、日本の食品メーカーであるミツカン（Mizkan）は、新たな納豆菌を発見し、独自の製法で発酵させることで納豆特有のにおいも糸引きもない納豆を製造・販売しています。この商品であれば、糸を引かないだけでなく、においの問題も起こらないので、宇宙に持っていくハードルが低くなります。[95]

図6. においもいと引きもない美納豆

そして、「におわなっとう」や「豆の文志郎」など、糸は引いてしまいますが、納豆の独特のにおいを抑えた商品はその他にも数種類存在しています。既に地上で消費者の要望によって開発されている商品が、宇宙で納豆を食べられるようにするためのハードルを下げてくれています。

図7. においが抑えられた納豆

さらに、国際宇宙ステーションは、各国のルールや制限が厳しく設定されていますが、民間宇宙船であれば、特にスペースX社のクルードラゴンやブルーオリジン社のニューシェパードなどのように操縦席すらなく、スイッチや機器類が表面に出ていない宇宙船であれば、現状の糸を引く状態の納豆であっても問題ないかもしれません。少なくとも、気球型で成層圏まで行くことのできるスペースパースペクティブ社やワールドビューエンタープライズ社が企画する成層圏宇宙旅行であれば、無重力にすらならないため、糸を引くことは特に問題にならないでしょう。

7. 結論（宇宙での食文化を広げるための可能性）

納豆は、一度宇宙食の申請をしてNASAから却下されてしまったため、その後は申請もされず宇宙食になっていません。時が経てば、新しく開発された技術によって可能になることも多く出てきます。納豆も第6項で述べたような、今現在の技術があれば納豆を宇宙に持って行くことも可能になっているでしょう。そして、さらに開発を進めて、地上で食べる時のように糸を引いても独特の臭いを発している状態でも宇宙で食することができるようになると、その技術で、納豆以外の食品でも、特徴がある食品を宇宙でも食べられるようになることでしょう。

また、宇宙空間や月や火星で人々が住み始めると、そこでできた食品で新たな食文化が生まれるでしょう。ASTRAXでは、宇宙での豊かな生活に貢献するために、引き続き食に関するサービスを考え、提供していきます。

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【77】Development of the space toilet called "Space Benking" 2023
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【80】The senses and creativity that can be achieved by bringing entertainment in space
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【84】Local revitalization project to turn my hometown, Komono Town, into "space town"
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【85】Methods and Practices for Introducing Private Space Education Programs into Japanese Schools
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