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DEVELOPMENT OF LAMEN EATEN IN SPACE

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Abstract

Currently, there are approximately 400 types of space food approved by NASA, Roscosmos, and JAXA. Since the advent of the commercial space travel era in 2021, the number of civilians traveling to space has been increasing, and with it, the variety of space food is expected to expand significantly. Among the challenges of space food development, one of the most difficult to consume in a microgravity environment is noodle dishes with liquid-based soup, such as ramen. The space ramen currently certified by JAXA consists of spherical noodles and thickened soup. While the taste resembles traditional ramen, the texture and eating experience are entirely different from that on Earth. To address this issue, ASTRAX has been developing various technologies to allow long-term space travelers to enjoy familiar foods in a way that closely replicates their terrestrial experience. The development of space ramen is a crucial part of this initiative. Such advancements are expected to play a significant role in the evolving era of commercial space travel by reducing stress for travelers and enhancing their enjoyment of food.
This paper explores methods for consuming noodle dishes with soup in microgravity and discusses future development plans.
Keywords: (maximum 6 keywords)

1. Introduction

As of 2025, there are said to be approximately 400 types of space food available to astronauts on the International Space Station. This number will likely be even more diverse if we include bonus foods, which are astronauts' personal favorites, and space foods from past spacecraft. While so many types of space food have already been eaten in space, all of these foods are intended for spaceflights related to national projects and are not intended for general space travelers.

With the start of general space travel aboard private spacecraft in 2021, the demand for a variety of space foods is expected to grow. This demand will require consideration not only of the type of food, but also of the method of serving and eating, as well as religious considerations and cooking methods tailored to individual tastes. It will be necessary to meet both the demand for "space-specific" eating styles and the demand for eating styles similar to those on Earth.

In this paper, we consider the possibility of providing noodles in liquid soup to general space travelers in space, using ramen as an example.

The method of investigation will involve two cases: when eating ramen, "eating it in a way that is unique to space" and "eating it the same way as on Earth."

However, since the former has already been developed through joint development between the Japanese space agency JAXA and a private company, this paper will focus on the latter.

2. Challenges of Noodles (Noodles with Soup) in a Zero-Gravity Environment

2.1 Space-Specific Noodles Adapted to the Space Environment

It's easy to imagine that eating noodles in liquid soup in a zero-gravity environment would be difficult, just like on Earth. The biggest problem is the difficulty of controlling the liquid soup. Taking this issue into consideration, Japan's JAXA and a private food manufacturer jointly developed instant ramen for space. This ramen is still available as one of the space food options for Japanese astronauts on the International Space Station.

This ramen is packaged in a special space food pack, thickened to increase viscosity and prevent the soup from splashing. The noodles are formed into balls, which are then mixed with the thick soup. This method can be said to have made it possible, if one is solely concerned with the taste of noodles.

For more details, see the references [ ].

2.2 Noodles Eaten in Space as They Are on Earth

The ramen certified as a JAXA Japanese Space Food in Section 2.1 tastes like ramen, but it lacks the texture and eating style typical of noodles—long, straight noodles slurped from a liquid soup like on Earth—and therefore does not provide the sensation of actually eating ramen. In other words, the original flavor of ramen is completely lost.

In the era of commercial space travel, ASTRAX prioritizes meeting all customer needs, and is researching and developing ways to make ramen "unique to space" possible, just as it is on Earth. Sections 3 and following describe ASTRAX's efforts.

3. ASTRAX's Space Food Development Initiative

3.1 Background of Space Food Research and Development for the Era of Private Space Travel

As space travel becomes more common and widespread, food needs in space will also diversify. While it is possible to force some compromises within the space environment and spacecraft constraints when developing space food for national astronauts, meeting customer needs is more important for private customers. Of course, compromising safety is unacceptable.

This is true not only for space food, but for general customers as well. Because the living environment in space is completely different from that on Earth, we must consider two approaches. One is to prioritize the space environment and develop products that are "unique to space." The other is to develop products that "achieve the same environment (conditions) in space as on Earth."

At ASTRAX, we consider both approaches in all space development projects because we never know which customers will desire. Therefore, as a private space service provider, we must always be prepared to meet both needs.

For example, here are some examples of the difference between "Developing space food unique to space" and "Developing space food that is edible like Earth food."

Unique to space / Same as Earth

Yakitori: Canned / Developed actual grilling equipment
Cold drinks: Keep at room temperature / Developed refrigerator
Alcohol: Cannot drink (or packaged) / Can drink
Beer: Cannot drink (or packaged) / Developed dedicated servers and mugs

Examples other than space food (for reference)
Bath: Wipe with a towel / Developed a space shower

3.2 Reasons for Development

The following are possible reasons for ASTRAX's development of space food.

- To be able to meet various customer needs
- Improving customer (space tourist) satisfaction
- The importance of being able to eat in space with the same experience as on Earth
(Psychological reassurance and stress relief) (See Reference [102])
- Space food certified by NASA and JAXA is often pre-packaged or commercially available retort pouches, which are unsuitable for space travelers seeking more luxury
- The desire to create a "space-specific presentation service"
, etc.

3.3 Challenges of Eating in a Zero-Gravity Environment

Possible challenges when eating space food in zero gravity include:

- Separation of liquid and solid matter
- Contamination and danger due to liquid splashing
- Changes in taste and difficulty in reproducing texture
- Psychological aspects (gap with eating habits on Earth)
- High development and delivery costs
, etc.

At ASTRAX, we believe that meeting customer needs and increasing customer satisfaction is more important than simply being "edible" as a minimum requirement, and we are therefore focusing on resolving these issues.

3.4 Food Shelf Life and Storage Methods

Space food has a shelf life and storage methods, which must be taken into consideration when serving it in space.

- Food shelf life is important for long-term travel.
- Storage period restrictions are less severe for short-term space travel.

- Storage techniques that maintain flavor and texture.
- Handling refrigeration or freezing if necessary.
- Storage methods for leftover ingredients and seasonings.

3.5 Serving Methods

When serving space food to NASA and JAXA astronauts and current space travelers to the International Space Station, it is common for each person to eat it directly from the package or can. However, as the number of space travelers increases in the future, various requests regarding the serving method of space food are likely to arise.

In this case, it will be necessary to consider both "space-specific serving methods" and "terrestrial-like serving methods."

- Fixing food to prevent it from floating / Intentionally floating food
- Presentation methods possible only in space (not possible on Earth) / Presentation methods similar to those on Earth
- Presentations possible only in space (not possible on Earth) / Presentations similar to those on Earth
- Eating methods possible only in space (not possible on Earth) / Eating methods similar to those on Earth
etc.

3.6 Food Waste Disposal Technology

An important issue that must be considered at the same time is how to dispose of leftover space food.

- Waste disposal technology
- Recycling system technology
etc.

4. Technical Approach to Space Ramen Development

4.1 Eating Experiments on a Zero-Gravity Aircraft

ASTRAX once conducted a ramen eating experiment using a zero-gravity aircraft for a television program.

For footage of the experiment, see Reference Material [ ].

In this experiment, boiled noodles and toppings were placed in a bowl while still heavy, soup was poured in from a water bottle, and the noodles were eaten once the zero-gravity environment was established.

As a result, in the zero-gravity environment, the liquid soup merged with the noodles due to surface tension, and when the noodles were pulled up with chopsticks, both the noodles and the soup were pulled up.

Since it is still edible in this state, we believe that when actually eating ramen in space, it may be possible to eat it in the same state as regular ramen (with low-viscosity soup and long, stretchy noodles) by taking measures to prevent the soup from splashing.

4.2 Cooking Methods for Noodles in a Zero-Gravity Environment

The following points need to be considered when cooking noodles in a zero-gravity environment.
- Use powdered soup and thin dried noodles, both of which can be added with hot water (extends shelf life).
- Use fresh noodles or liquid soup (shortens shelf life).
- Select noodles that can be rehydrated in 70°C water.
- Separate consideration is needed for handling ingredients (they may stick together or fly apart with the noodles).
- Consider the shape and handling method of ingredients to make them easy to eat in zero gravity.
- Further consideration is needed for containers and serving methods.

5. User Experience

Rather than considering it technically impossible, we consider how to meet customer needs. To improve space food technology, we need to explore a wider range of needs and develop technologies to meet them. To that end, we believe it is important to increase opportunities to experience space food for space travel.

- Examining the impact of the "pleasure of eating" on mental health during long-term space stays
- Development and application of space food technology for public stay scenarios in space hotels and lunar bases
- "Space ramen experiences" at space events on Earth

etc.

6. Future Development Plans

ASTRAX plans to continue developing space food (including beverages) technology with a focus on how to meet customer needs and improve customer satisfaction, regardless of spacecraft or technical constraints.

・Expansion to other noodle types (udon, soba, pasta)
・Expansion to other space foods (including beverages)
・ Establishment of long-term storage and mass production technologies
・Establishment of food waste disposal technology and recycling systems
・Potential application to disaster relief and medical food on Earth
・Demonstration experiments using zero-gravity aircraft and simulators

etc.

7. Conclusion

To date, space food development has focused on providing optimal (or minimal) solutions within various constraints. However, ASTRAX does not consider these constraints within itself, but instead focuses on how to overcome them. This is because space food development offers endless possibilities for the era of private space exploration.

In future private space travel and long-term stays, space food will likely evolve in various directions, from "nutritional intake for survival" to "food culture for enjoyment" and "creating a space experience that enhances the unique environment of space."

Furthermore, it will be important to develop diverse space food that takes into account the diverse food cultures and religious restrictions of each country.

At ASTRAX, we hope to promote the expansion of human habitation into space through the development of not only space ramen, but also various other space foods.

We believe that the technological developments and results achieved through this endeavor will also contribute to making life on Earth even richer and more comfortable.

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宇宙で食べるラーメンの開発

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Abstract

Currently, there are approximately 400 types of space food approved by NASA, Roscosmos, and JAXA. Since the advent of the commercial space travel era in 2021, the number of civilians traveling to space has been increasing, and with it, the variety of space food is expected to expand significantly. Among the challenges of space food development, one of the most difficult to consume in a microgravity environment is noodle dishes with liquid-based soup, such as ramen. The space ramen currently certified by JAXA consists of spherical noodles and thickened soup. While the taste resembles traditional ramen, the texture and eating experience are entirely different from that on Earth. To address this issue, ASTRAX has been developing various technologies to allow long-term space travelers to enjoy familiar foods in a way that closely replicates their terrestrial experience. The development of space ramen is a crucial part of this initiative. Such advancements are expected to play a significant role in the evolving era of commercial space travel by reducing stress for travelers and enhancing their enjoyment of food.
This paper explores methods for consuming noodle dishes with soup in microgravity and discusses future development plans.

Keywords: Ramen, space food, ASTRAX

アブストラクト

NASAやロシア、JAXAが認定している宇宙食は400種類くらいあると言われている。2021年に民間宇宙旅行時代が始まり、今後多くの一般人が宇宙に行くようになると、宇宙食のレパートリーは格段に多くなっていくだろう。宇宙食の中で、無重力の環境の中で食べるものが難しいものとして、ラーメンなどの液体のスープに入った麺類がある。現在JAXAが認定している宇宙食用ラーメンは、麺は玉状で、スープはとろみがあり、味はラーメンでも、食べた時の感覚は全くラーメンとは別のものとなっている。ASTRAXでは、これから長期で宇宙旅行に行く人たちが、普段地球で食べているものを、地球で食べている感覚に近い状態で食べられるようにするために、様々な技術開発を行っており、宇宙ラーメンの開発もその一環である。このような開発は、これからますます発展していく民間宇宙旅行時代において、搭乗者のストレスを緩和し、食べることの楽しみを増加させるために非常に役立つと考えている。
本論文では、スープに入った麺類を無重力で食べるための方法についての検討結果とこれからの開発計画について発表を行う。

キーワード: ラーメン、宇宙食、ASTRAX

1. はじめに

2025 年現在、国際宇宙ステーションの宇宙飛行士が食べることができる宇宙食は 400 種類ほどあると言われている。さらに、ボーナスフードと呼ばれる、宇宙飛行士が個人的に食べたいものを持ち込む場合や、過去の宇宙船の宇宙食などを含むとさらにその種類は多様なものとなるだろう。すでにこれだけたくさんの宇宙食が宇宙で食べられているが、これらはすべて、国家事業に関わる宇宙飛行を行うものが食べられるものであり、一般の宇宙旅行者向けに作られているものではない。

2021 年から民間各社の宇宙船による一般的な宇宙旅行が現実的に始まり、今後、ますます様々な宇宙食の

ニーズが高まって行くことが予想される。そのニーズとしては、種類だけでなく、提供方法や食べ方などに始まり、宗教的な配慮や、個人個人の味の嗜好に合わせた調理方法などを考慮し、『「宇宙ならでは」の食べ方に対する需要』と、『地上と同様の食べ方に対する需要』に応えて行く必要が出てくるだろう。

本論文では、その中で、一般宇宙旅行者に対して宇宙で液体スープに入った麺類を提供することを想定し、ラーメンを例に取って検討を行う。

検討方法としては、ラーメンを食べる際、『「宇宙ならでは」の方法で食べる場合』と、『地上と同様に食べる場合』について検討を行う。

ただし、前者については、すでに日本の宇宙機関の JAXA と民間企業の共同開発によってすでに開発されているため、本論文では後者を中心に検討を行うこととする。

2. 無重力環境における麺類（スープを伴う麺類）の課題

2.1 宇宙環境に適用させた宇宙専用の麺類の場合

無重力環境において、液体スープに入った麺類を地上のように食べることが難しいことは容易に想像がつくだろう。いちばんの問題は「液体」であるスープの制御の難しさがあることである。その問題を考慮して、日本の JAXA と民間食品メーカーが共同で、宇宙用のインスタントラーメンの開発を行った。このラーメンは、現在でも国際宇宙ステーションの日本人宇宙飛行士が食べる宇宙食のメニューの一つとして選択することが可能となっている。

このラーメンは、宇宙食専用のパックに入っており、スープが飛び散らないようにとろみを付けて粘度を増加させていて、麺はボール状にまとまっていて、そのボール状の麺ととろみのあるスープを絡めて食べる方法をとっている。この方法により、味だけを考慮して麺類を食べるということだけを考えたら、実現されていると言っていいだろう。

詳細は参考文献【】を参照。

2.2 宇宙環境において地上と同様に食べる麺類の場合

2.1 項に示している JAXA 宇宙日本食に認定されているラーメンは、味はラーメンではあるものの、地上のような液体状のスープのなかから、長く伸びた麺をすするという、麺類特有の食感と食べ方ではないため、ラーメンを食べているという感覚は得られない。つまり、本来のラーメンらしさが完全に失われているのである。

民間宇宙旅行時代において、あらゆる顧客ニーズに応えることを第一として考えている ASTRAX としては、「宇宙ならでは」のラーメンと同様に、「宇宙で地上と同じようにラーメンを食べられるようにすること」を実現させるために検討や開発を行っている。3 項以降に ASTRAX の取り組みを示す。

3. ASTRAX の宇宙食開発の取り組み

3.1 民間宇宙旅行時代に向けた宇宙食研究開発の背景

宇宙旅行が一般化し広がって行くと、宇宙での食のニーズも多様化してくことになる。国の宇宙飛行士のための宇宙食開発では、宇宙環境や宇宙船の制約の中である程度の妥協を強要することができるが、一般顧客に対しては、いかに顧客ニーズに応えて行くかの方が重要となる。もちろん安全を侵すようなことは許されない。

宇宙食に限らず言えることだが、宇宙での生活環境は地上とは全く異なる環境であることから、2つの方向性で考える必要がある。1つは宇宙の環境を優先し、「宇宙ならでは」な開発を行うこと。そしてもう一つは、「地球と同じ環境（状態）を宇宙で実現させる」ための開発を行うことである。

ASTRAX では、すべての宇宙開発において、この両方を考慮して行っている。なぜなら、顧客がどちらを求もとめるかがわからないからである。そのため、民間宇宙サービス事業者としては、常にどちらのニーズにも対応できるようにしておく必要がある。

例えば、『「宇宙ならでは」な宇宙食開発』と、『地球と同様に食べられる宇宙食開発』の違いについていくつかの例を示す。

	宇宙ならでは/地球と同様
焼き鳥	缶詰/実際に焼く装置を開発
冷たい飲み物	常温で我慢/冷蔵庫開発
アルコール	飲めない（あるいはパック）/飲める
ビール	飲めない（あるいはパック）/専用のサーバーやジョッキを開発

宇宙食以外の例（参考）

風呂	タオルで拭く/宇宙シャワーを開発

3.2 開発理由

ASTRAX の宇宙食開発の理由としては以下の理由が考えられる。

・さまざまな顧客のニーズに応えられるようにするため
・顧客（宇宙旅行者）の満足度向上
・宇宙でも地上と同じ感覚で食べられることの重要性
（心理的安心・ストレス緩和）（参考文献【102】参照）
・NASA や JAXA が認定する宇宙食は、パック詰めであったり市販されているレトルト商品が多く、より贅沢を求める宇宙旅行者にとっては適さない
・『宇宙ならではの演出サービス』を作り出したい
など

3.3 無重環境下での摂食における課題

無重力状態において宇宙食を食べる際の課題としては以下のようなものが考えられる。

・液体と固形物の分離
・液体が飛び散ることによる汚染や危険性
・味覚の変化と、食感の再現性の難しさ
・心理的側面（地球上での食習慣とのギャップ）
・高額な開発コストや提供コスト
など

ASTRAX では、最低限の要求として「食べられればいい」のではなく、いかに顧客のニーズに応え、いかに顧客満足度を高めるかということを重要と考えているので、あえてこれらの課題を解決することに注力している。

3.4 食料保存期間・保存方法

宇宙食には保存可能な期間や保存方法があるため、宇宙で提供する際はそれらを考慮する必要がある。

・長期滞在型の旅行向けでは、食料保存期間が重要
・短期の宇宙旅行では保存期間への制約は低い
・風味や食感を損なわない保存技術
・冷蔵や冷凍が必要な場合の対処
・開封し残った材料や調味料などの保存方法
など

3.5 提供方法

NASA や JAXA の宇宙飛行士や、現在の国際宇宙ステーションへの宇宙旅行者に対して宇宙食を提供する際は、各自パックや缶詰などから直接食べることが当たり前であるが、今後宇宙旅行者が増えていくにつれて、宇宙食の提供方法に対してもさまざまな要望が出てくることが考えられる。
この場合『宇宙ならではな提供方法』と、『地上と同様の提供方法』の両方を考慮する必要があるだろう。

・浮遊させないように固定/あえて浮遊させる
・宇宙だからこそできる（地上ではできない）盛り付け方法/地球と同様の盛り付け方法
・宇宙だからこそできる（地上ではできない）演出/地球と同様の演出
・・宇宙だからこそできる（地上ではできない）食べ方/地球と同様の食べ方
など

3.6 残飯処理技術

食べ残した宇宙食の処理の方法も同時に考えておかなければならない重要な事項である。

・廃棄処分技術
・循環システム技術
など

4. 宇宙ラーメン開発の技術的アプローチ

4.1 無重力飛行機による実食実験

ASTRAX では、テレビ番組の撮影のために、無重力飛行機を利用したラーメンの摂食実験を行ったことがある。その時の映像については参考資料【】を参照。

このときは、重量があるうちに茹でた状態の麺や具材を器に入れ、水筒からスープを注いでおき、無重力状態になってから食べるという実験を行った。

その結果、無重力状態になると表面張力により液体状のスープは麺と一体化し、箸で麺を引き揚げると、麺とスープが両方とも引き上げられてしまった。

一応その状態でも食べることは可能であるため、実際に宇宙で実食する際は、スープが飛び散らない工夫をすることで、通常のラーメン（粘度が低いスープと長く伸びた状態の麺）の状態で食べることができるのではないかと考えている。

4.2 無重力環境における麺類の調理方法

無重力状態での麺類の調理方法としては、以下のようなことを検討する必要がある。

・スープは粉状、麺は細麺の乾麺、どちらもお湯を入れる（保存期間が長くできる）
・生麺や液体スープを使用（保存期間はは短くなる）
・70 度のお湯で戻せる麺を選定
・具材の扱いを別途考える必要がある（麺とともにくっついてきてしまったり飛散する可能性がある）
・無重力でも食べやすい具材の形状や処理方法を検討
・容器や食べ方についてさらに検討が必要

5. 利用者体験

技術的に不可能と考えるのではなく、顧客のニーズにいかに応えるかという視点で考えると、宇宙食技術の向上のためには、よりたくさんのニーズを開拓し、それに応えるための技術開発を行なっていく必要がある。そのためにも、宇宙旅行用の宇宙食を体験する機会を増やしていくことが重要だと考えている。

・「食べる楽しみ」が長期宇宙滞在のメンタルヘルスに与える影響を検討
・宇宙ホテルや月面基地での一般人滞在シナリオにおける宇宙食技術の開発と応用
・地上における宇宙イベントなどでの「宇宙ラーメン体験」
など

6. 今後の開発計画

ASTRAX では、これからも、宇宙船や技術的な制約にとらわれず、いかに顧客のニーズに応え、顧客の満足度を向上させるかという観点で宇宙食（飲み物を含む）の技術開発を行っていく予定である。

・他の麺類（うどん、そば、パスタ）への展開
・その他の宇宙食（飲み物を含む）への展開
・長期保存・量産化技術の確立
・残飯処理技術及び循環システムの確立
・地上の防災食や医療食への応用可能性
・無重力飛行機やシミュレーターでの実証実験
など

7. 結論

これまでの宇宙食開発においては、さまざまな制約の中で最適な（あるいは最低限の）方法での宇宙食の提供が行われてきたが、ASTRAX では、そもそもそれらの制約の中で考えるのではなく、それらの制約をどのようにしてクリアしていくかという観点で宇宙食開発を行っている。民間宇宙開拓時代に向けた宇宙食開発には無限の可能性があるからである。

今後の民間宇宙旅行・長期滞在においては、宇宙食は「生きるための栄養摂取」から「楽しむための食文化」「宇宙という特殊な環境の経験の価値を高めるための演出」など、さまざまな方向性で進化していくだろう。

また、国ごとに違うさまざまな食文化や宗教的な制約なども考慮した、多様な宇宙食開発が重要になっていく。

ASTRAX では、宇宙ラーメンの開発に限らず、さまざまな宇宙食開発を通じて、人類の生活圏の宇宙への拡大を促進していきたいと考えている。

そしてそのための技術開発や成果は、地上での生活をさらに豊かにし、快適にしていくためにも貢献するものと考えている。

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