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SAMPLE LANDSCAPE STUDY
Non-Thermal Pasteurization

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1. INTRODUCTION

1.1. Non-Thermal Pasteurization (NTP)

Food preservation is a continuous fight against microorganisms spoiling the food or making it unsafe. Until recently, thermal processes, especially ultra-high temperature (UHT) and high temperature short time (HTST) have been the most commonly used methods in the food industry to increase shelf-life and maintain food safety. However, studies have shown that heat degrades product color, flavor, and nutrients because of protein denaturation and the loss of vitamins and volatile flavors. Therefore, there is increasing demand for alternative methods for fresh food pasteurization that ensure safety while decreasing product degradation.

Non-thermal physical processes are evolving as potential alternatives to thermal and chemical operations in food processing. Non-thermal methods allow the processing of foods below temperatures than that used in thermal pasteurization, so flavors, essential nutrients, and vitamins undergo minimal changes or even no changes.

Non-thermal pasteurization (NTP), also known as cold pasteurization is evolved as a potential alternative food processing technology the food industry and consumers have significant interest because the NTP process offer better quality and nutrition retention and are more energy efficient than traditional thermal processes as it doesn't expose the food to elevated temperatures thereby retaining the color, flavor, taste, appearance and other features increased the shelf life of food. Non-thermal processes may also create value-added products and open new market opportunities for the investors.

The most investigated non-thermal pasteurization technologies are high pressure process (HPP) or high hydrostatic pressure (HHP), pulsed electric fields (PEF), irradiation, UV light, non-thermal or cold plasma, dense phase carbon dioxide (DPCD) or super critical carbon dioxide. Some of these processes have been studied extensively for at least two decades, but none of these alternative processes is in large-scale commercial practice for fruit juice and milk pasteurization due to technical issues or, more often, economic disadvantages. The high resistance of enzymes and bacterial spores to these processes is also a major problem. Efforts are needed to improve these processes or develop new processes. It is also suggested that combinations of these processes and

For sources of information, please refer to **Appendix A**

other methods, which are termed `hurdle technology', may present potential benefits and practical uses of these processes.

High Pressure Processing (HPP)

HPP also referred to as UHP or HHP is a known food preservation technique by inactivating spoilage and pathogenic microorganisms in either solid or liquid food with or without packaging under high pressure conditions. The technique consists of subjecting food to pressures between 100 and 800 MPa for a few seconds to a few minutes with process temperatures are less than 100 °C.

Food treated in this process has been shown to retain its original freshness, colour, flavour and taste. HPP acts instantaneously and uniformly throughout the food and is also feasible at room temperature compared to heat treatment. HHP generally produces better results for the pasteurization of foods when combined with initial temperatures around 45±50 °C.

However, besides destruction of micro-organisms there are questions about the influences of pressure on food materials like protein denaturation or modification, enzyme activation or inactivation, changes in enzyme–substrate interactions, changes in the properties of polymer carbohydrates and fats. But these effects are small as compared to the influence of temperature in traditional thermal food processing methods. The chemical changes in HPP processed foods are minimal as the breakage of covalent bonds does not occur. Therefore, it ensures sensory properties, nutrients, and particularly bioactive suffer during the pasteurization.

Pulsed Electric Field (PEF)

High intensity pulsed electric field (PEF) process involves the application of short pulse of high voltage (typically 20±80 kV/cm) to food materials which are static or flowing through a treatment chamber. PEF is a continuous processing method, which is not suitable for solid food products that are not pumpable. Pulsed electric field technology has been successfully demonstrated for the pasteurization of foods such as juices, milk, yogurt, soups, and liquid eggs. Application of PEF processing is restricted to food products with no air bubbles and with low electrical conductivity. This process attains a 5 log reduction on most pathogenic bacteria by rupturing the cell membranes in liquid media.

There are a number of drawbacks in the application of PEF technology to foods. First, ohmic (electro-resistive) heating occurs during the PEF discharge, which causes the temperature of the sample to rise, and hence a cooling system has to be in place in order to maintain as closely as possible the initial, lower temperature of liquid samples.

For sources of information, please refer to **Appendix A**

Therefore, a significant amount of energy is dissipated by the unwanted heating up and necessary cooling of the liquids. Second, since the electrodes have to be immersed in the liquid, they contribute a major source of contamination to the liquid food due to the erosion of the electrodes that occurs during discharge. Finally, the initial equipment investment is very capital-intensive and presents a major obstacle for the commercial application of PEF technology.

Ultrasonication

Sonication is a non-thermal processing in which sound waves having frequency more than 18 kHz applied for processing and preservation of food without affecting the nutritional quality. High-intensity ultrasonic pasteurization of foods and beverages is an emerging technique that permits achieving the required levels of microbial inactivation at much lower temperatures (about 40 °C), which does not deteriorate the quality of the products. High-amplitude ultrasound-promoted pasteurization is the result of intense acoustic cavitation that generates violently imploding vacuum bubbles and causes micro-jets that are lethal to microorganisms.

Irradiation

Irradiation pasteurization is a non-thermal food pasteurization process that reduces or kills bacteria and other pathogens in food by exposing it to high-energy rays such as gamma rays from radio isotopic sources e.g., Cobalt60 or Cesium137, electrons, X-rays from electron beam accelerators, or ultraviolet (UV) sources. Irradiation processes minimize post-harvest loss and decrease perishability in products such as potatoes. Irradiation technique can be also used to post-packaging food materials including the disinfection of grains, legumes, spices, fruits, melons, lettuces, vegetables and tubers, colour retention in fresh meats and microbiological control in eggs, pork, poultry and meat. Not all foods are suitable for irradiation processes. Milk and other protein foods can develop off-flavour, odour and colour, and some fruits may exhibit softening and discolouration, especially at higher dose levels.

Microwave Volumetric Heating (MVH)

Use of microwave heating is gaining popularity in food processing for its ability to achieve high heating rates, significant reduction in cooking time, more uniform heating, safe handling, ease of operation and low maintenance. Microwave Volumetric Heating (MVH) is a method of using microwaves to evenly heat food material and the changes in flavor and nutritional qualities of food in a lesser extent as opposed to conventional thermal process. In contrast to traditional thermal processing, food

For sources of information, please refer to **Appendix A**

materials heated by MVH do not come into contact with hot surfaces and this minimizes thermal damage to functional components, and allows thick and viscous products to be heated without fouling or damaging.

Dense Phase Carbon Dioxide

Food processing with Dense Phase Carbon Dioxide (DPCD) is a non-thermal process where the processing technology uses pressurized CO_2 in the liquid, gaseous or supercritical fluid states. DPCD has been shown to inactivate microorganisms in liquid foods as good as conventional heat pasteurization without the loss of nutrients or quality changes that may occur due to thermal effects. The effects of DPCD on microorganisms, enzymes and quality attributes in liquid foods have been studied well and the applications of DPCD to solid foods gaining interest recently. Also, the synergistic effects of simultaneous application of different non-thermal technologies together with DPCD are becoming the centre of research in this area.

Non-thermal Plasma or Cold Plasma

Cold plasma is a relatively new method of non-thermal pasteurization technique. Cold plasmas or non-thermal plasmas are known for their bactericidal properties without heat effects and have been successfully tested for sterilization or processing of various food products. Plasma is a form of ionized gas and is produced by applying an electric current to a neutral gas. Plasma contains reactive oxygen species (ROS) and reactive nitrogen species (RNS) that cause oxidative damage to the outer membranes and DNA of microorganisms resulting in death.

Apart from the above techniques there are other non-thermal pasteurization methods available which include strong pulse light technique, centrifugation and microfiltration, ion selective diffusion, and enzymatic pasteurization etc.

1.2. Growth Prospects of Non-Thermal Pasteurization

The global non-thermal pasteurization (NTP) market is expected to reach USD 2.5-3 billion by 2023, at a CAGR of 19-20% attributing to growing consumption of convenience foods such as ready to eat foods, frozen food, and packaged foods, reduction of the processing time by use of NTP and increase in the production capacity to meet the increased market demands.

The non-thermal pasteurization technology preserves the freshness of food products and helps in extending the shelf life without any preservatives and additives. This will help in raising the consumer demand for natural, fresh, and minimally processed foods.

By technique, the PEF segment is estimated to grow at the highest CAGR in the next five

For sources of information, please refer to Appendix A

years. By product, the beverages segment is estimated to grow at the highest CAGR during the coming years due to increasing acceptance of non-thermal pasteurization techniques in processed fruit & vegetable juices, wine, sugar syrups, beer, milk, and processed coconut water. By food form, the solid segment is estimated to have a larger market share in future due to the usage of non-thermal pasteurization techniques in food products such as cheese, jellies, jam, processed food, meat products, etc.

It is a critical time to understand the global competitive environment of non-thermal pasteurization market from a patent perspective and in-depth patent analysis of key technologies and players can help anticipate changes, detect business opportunities, mitigate risks and make strategic decisions to strengthen one's market position and maximize return on one's IP portfolio.

Some of the prominent participants in the global market of NTP are Hiperbaric Espana (SPAIN), Avure Technologies (US), Thyssenkrupp AG (Germany), Kobe Steel Ltd (Japan), Bosch (Germany), Chic Freshertech (US), Elea Technology (Germany), Pulsemaster (Netherlands), Nordion (Canada), Multivac Sepp Haggenmuller SE & CO. KG (Germany), Stansted Fluid Powder Ltd (UK), Symbios Technologies (US), Dukane Corporation (US), Gray*star (US), and Universal Pure (US).

For sources of information, please refer to **Appendix A**

2. OBJECTIVES

- To perform detailed analysis of granted patents and published applications pertaining to non-thermal pasteurization and to understand underlying technologies.
- In depth analysis of patents/applications, in order to categorize them and to understand focusing areas of applicants.
- Graphical representation of trends (Filing, Publication, etc.) from the mined data of relevant patents/applications.

Image Courtesy

2.1 SEARCH METHODOLOGY

Image Courtesy

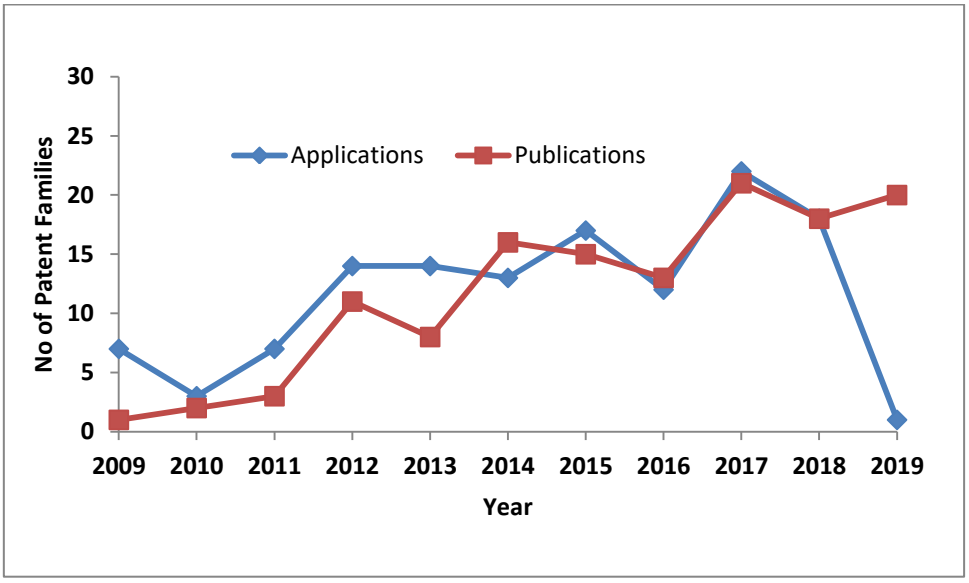
The first step is to create and define a patent set that will serve as the basis of analysis. Using renowned patent database, Derwent Innovation as our data source, we extracted data set of patents/published applications filed during the last ten years (2009-2019) by performing search in Abstract, Title, and Claims fields using keywords and International Patent Classifications.

3. TREND ANALSYS & GRAPHICAL REPRESENTATION

3.1 APPLICATION AND PUBLICATION YEAR BASED TREND ANALYSIS

3.1.1 ANALYSIS BASED ON REPRESENTATIVE MEMBER PER INPADOC FAMILY

Below graph represents application year and publication year based trends for the patent publications pertaining to Non-Thermal Pasteurization.



Note: Attributed to non-published patent applications, there may be a higher count in the years 2018- 2019.

INSIGHT:

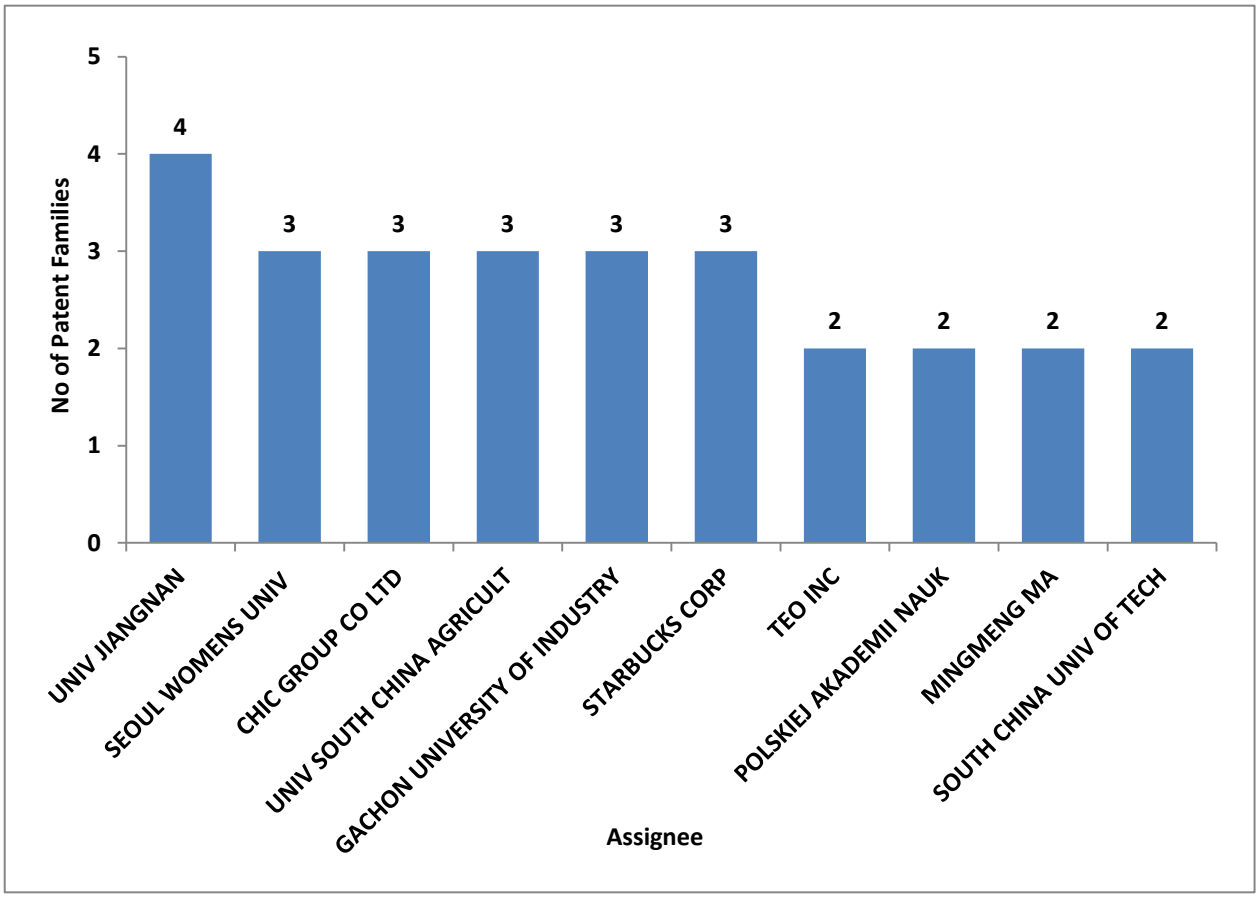
- Filing year trend provides insights for the number of applications filed during the period 2009-2019. As depicted in the graph, there is an overall rise in patent applications filing over the years, wherein the maximum number of patent applications (22) were filed in the year 2017.

- Publication trend provides insights for the number of applications published during the period 2009-2019. As indicated in the graph, there is a gradual rise in publication over the years, wherein the maximum number of patent applications (21) were published in the year 2017.

3.2 ASSIGNEE BASED TREND ANALYSIS

3.2.1 MAJOR ASSIGNEES (BASED ON REPRESENTATIVE MEMBER PER FAMILY)

The below graph represent major assignees in the domain.



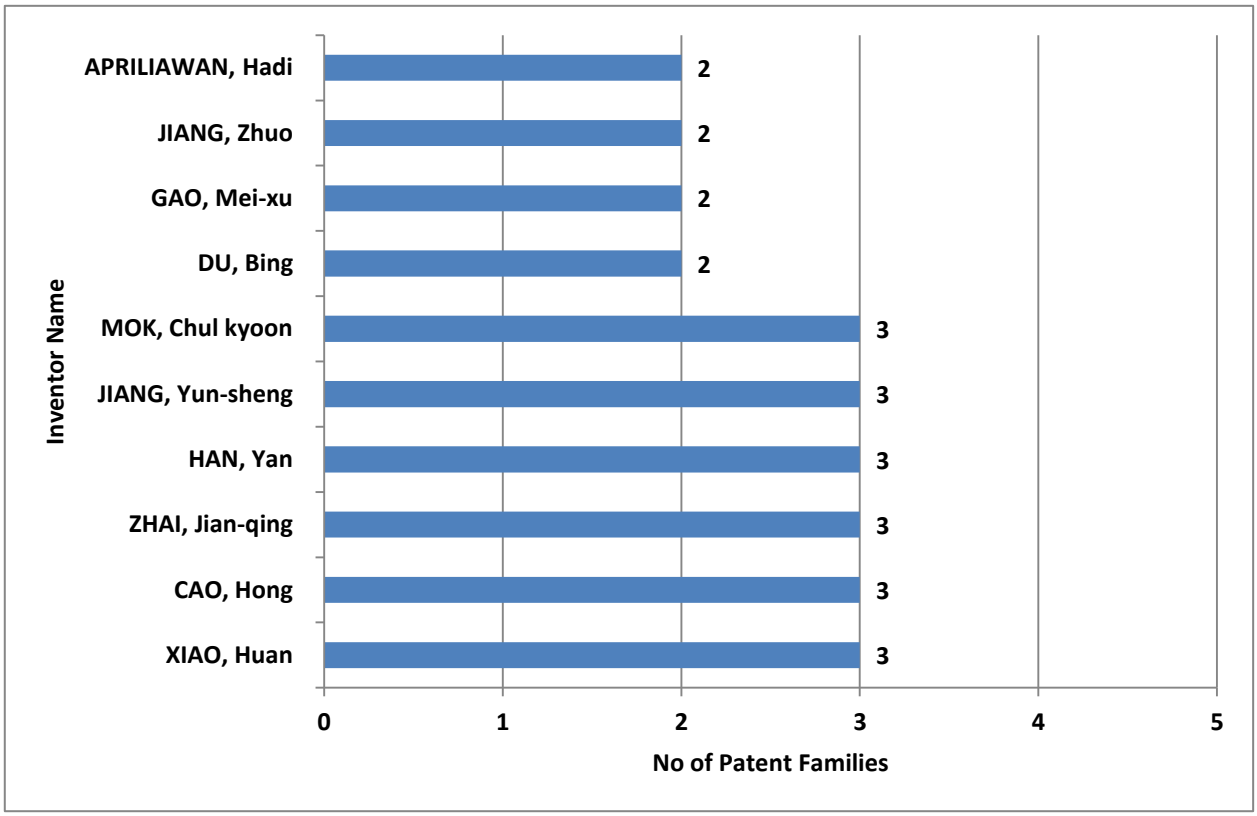
THE TOP ASSIGNEES ARE:

- UNIVERSIT OF JIANGNAN
- SEOUL WOMENS UNIVERSITY
- CHIC GROUP CO LTD
- UNIVERSITY OF SOUTH CHINA AGRICULTURE
- GACHON UNIVERSITY OF INDUSTRIES

- STARBUCKS CORP
- TEO INC
- POLSKIEJ AKADEMI NAUK
- MINGMENG MA
- SOUTH CHINA UNIVERSITY OF TECHNOLOGY

3.3 KEY INVENTORS

The below graph names the inventors with most number of innovations on their name.



INSIGHT:

The chart demonstrates top inventors, wherein **'MOK, Chul Kyoon**, '**JIANG'**, **Yun-sheng', 'HAN, Yan', ZHAI, Jian-qing', 'CAO, Hong' & 'XIAO, Huan'** emerged out as the leading inventors in Non-Thermal Pasteurization domain.

3.4 GEOGRAPHY BASED TREND ANALYSIS

3.4.1 GEOGRAPHICAL DISTRIBUTION OF PATENT APPLICATION FILINGS

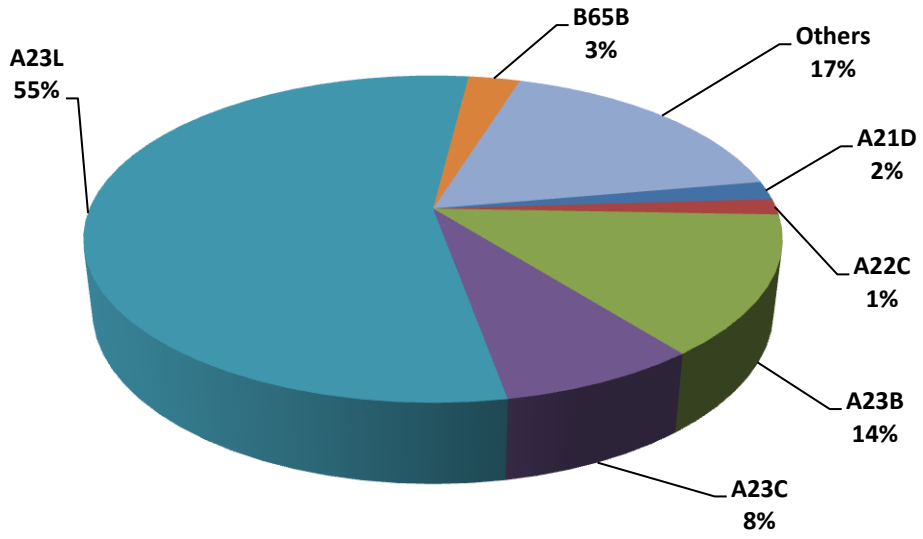
Priority Country → / Priority Year ↓	AU	CN	DK	EP	ES	GB	ID	IN	IT	JP	KR	NL	PL	PT	US	WO	Grand Total
2004															1		1
2008										1					3		4
2009		3								1							4
2010		3													2		5
2011		3		2	2	1	2			1		1			2		14
2012		4							1	1	4						10
2013		7						1			2		2		3		15
2014		11		1											4		16
2015	2	9				1				2					3	1	18
2016		6							1	1	1				3		12
2017		13	1			1		2	1		2			1			21
2018		11															11
2019															1		1
Grand Total	**2**	**70**	**1**	**3**	**2**	**3**	**2**	**3**	**3**	**7**	**9**	**1**	**2**	**1**	**22**	**1**	**132**

INSIGHT:

Trend related to Geographical filing demonstrates that the maximum number of filings originated from CN jurisdiction (70) followed by US (22), KR (9) and JP (7) jurisdictions.

3.5 INTERNATIONAL PATENT CLASSIFICATION BASED TREND

The below graph represents frequently assigned international patent classes.



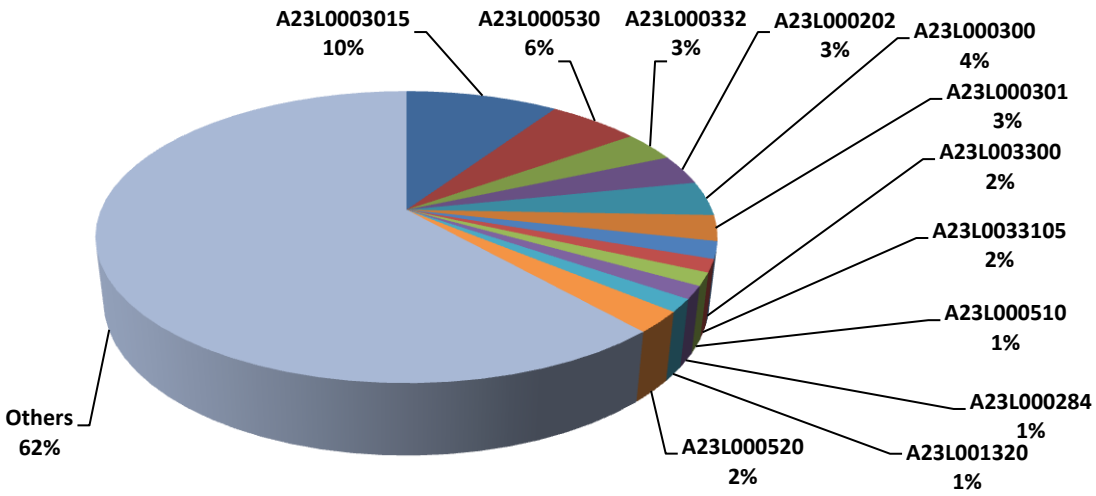
INSIGHT:

Majority of patent applications were assigned with IPC "**A23L**" related to 'FOODS, FOODSTUFFS, OR NON-ALCOHOLIC BEVERAGES, THEIR PREPARATION OR TREATMENT, e.g. COOKING, MODIFICATION OF NUTRITIVE QUALITIES, PHYSICAL TREATMENT PRESERVATION OF FOODS OR FOODSTUFFS, IN GENERAL followed by "**A23B**" related to 'PRESERVING, e.g. BY CANNING, MEAT, FISH, EGGS, FRUIT, VEGETABLES, EDIBLE SEEDS; CHEMICAL RIPENING OF FRUIT OR VEGETABLES; THE PRESERVED, RIPENED, OR CANNED PRODUCTS'.

3.5.1 INTERNATIONAL PATENT SUB-CLASSIFICATION BASED TREND

The below graph represents sub-classes pertaining to one of the top/main patent classes.

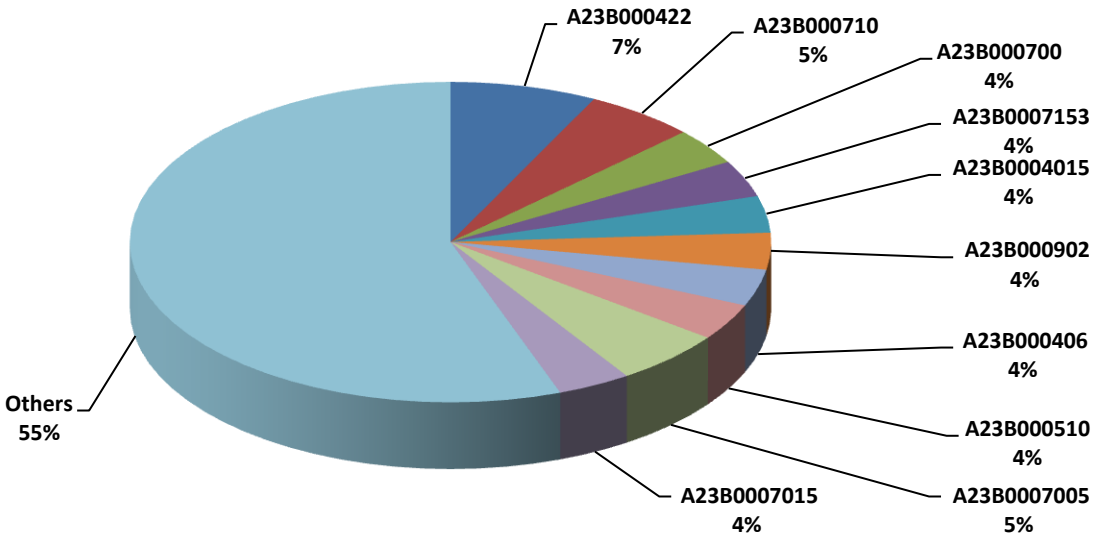
A23L Sub-Classification



INSIGHT:

"**A23L0003015**" emerged as major subclass which relates to compositions containing "by treatment with pressure variation, shock, acceleration or shear stress".

A23B Sub-Classification



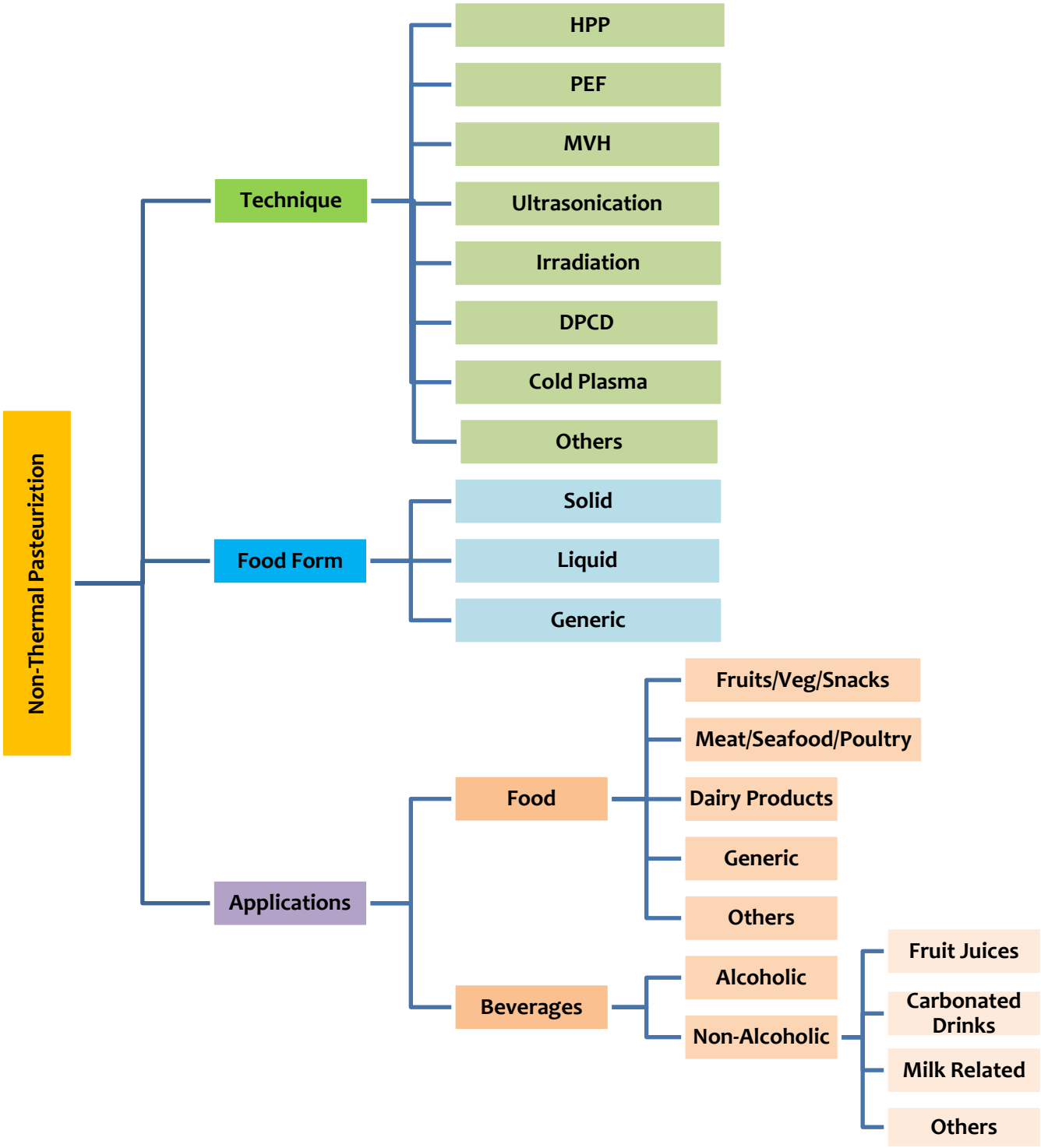
INSIGHT:

"**A23L000422"** emerged as major subclass which relates "General methods for preserving meat, sausages, fish or fish products".

4. KEY TECHNOLOGICAL TRENDS

4.1 TAXONOMY DEVELOPED FOR BUCKETING OF RELEVANT PATENT DOCUMENTS

A set of 132 patent families were analyzed in depth to identify the focus areas of the patents related to Non-Thermal Pasteurization techniques



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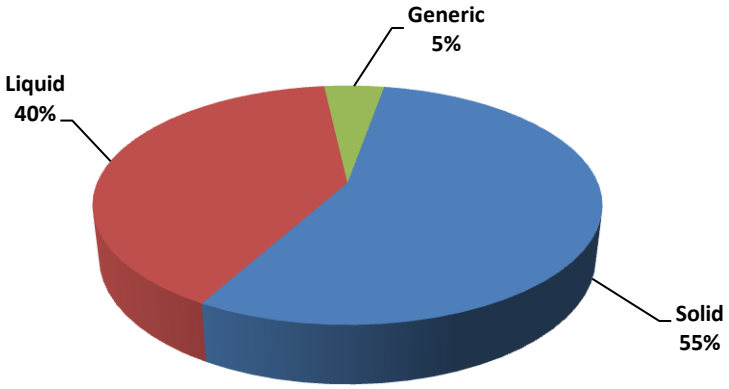
4.2 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO FOOD FORM PASTEURIZED

Below representation shows the dissection in terms of food form subjected to Non-Thermal Pasteurization.

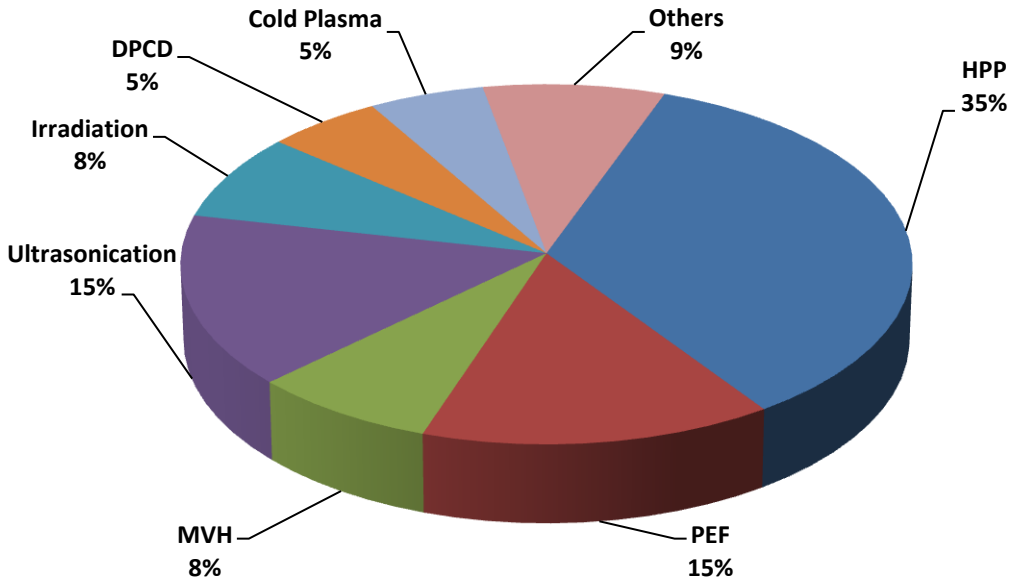


INSIGHT:

As evident from the graph, 55% of patents/applications disclosed solid food pasteurization while 40% of patents/applications are disclosed pasteurization of liquid food products.

4.3 DISTRIBUTION OF PATENTS/APPLICATIONS PERTAINING TO NON-THERMAL PASTEURIZATION TECHNIQUES

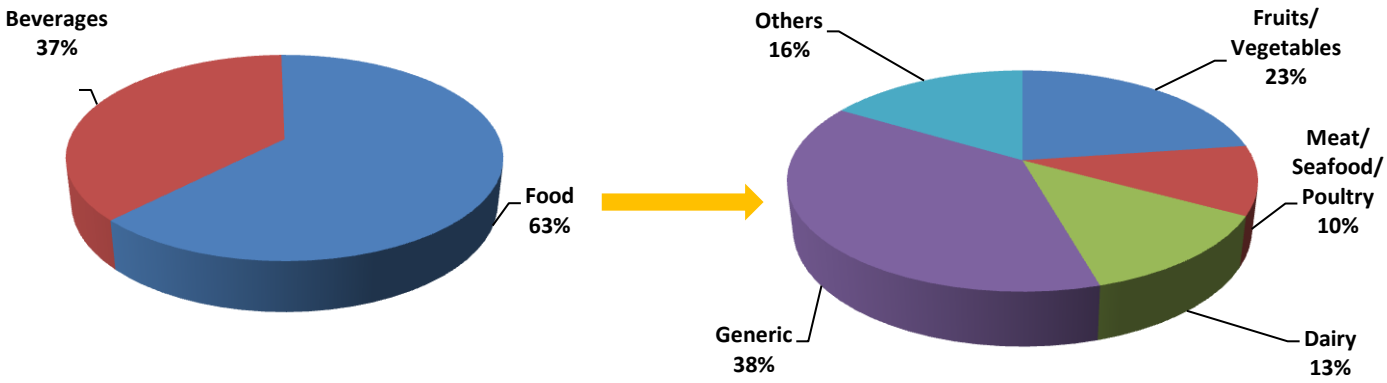
This category deals with patents/applications pertaining NTP technique employed.



INSIGHT:

As evident from the graphs, 35% of patent filings disclose high pressure processing (HPP) non thermal pasteurization technique followed by pulsed electric field (15%) and ultrasonication (15%).

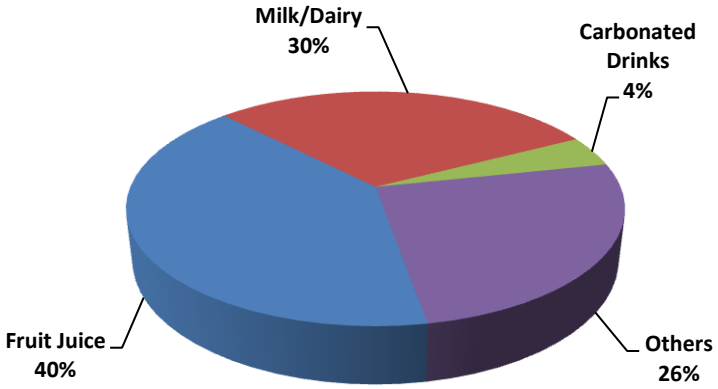
4.4 DISTRIBUTION OF PATENTS/APPLICATIONS BASED ON APPLICATION AREA



INSIGHT:

As evident from the graph, 63% of patent filings disclosed pasteurization of food products while 37% disclosed pasteurization of beverages. Amongst food products, 23% of patent filings focused on pasteurization of fruits/vegetables/snacks

4.4.1 BEVERAGES SUB-CATEGORIZATION TREND



INSIGHT:

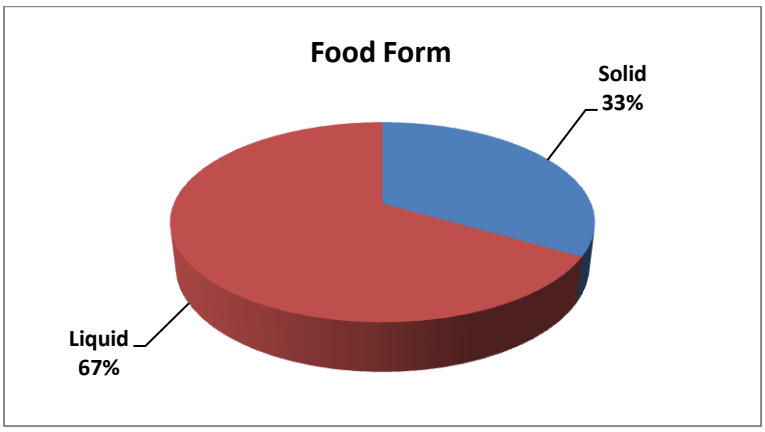
As evident from the graph, majority of patent filings (40%) disclose pasteurization of fruit juices followed by milk/diary related beverages (30%).

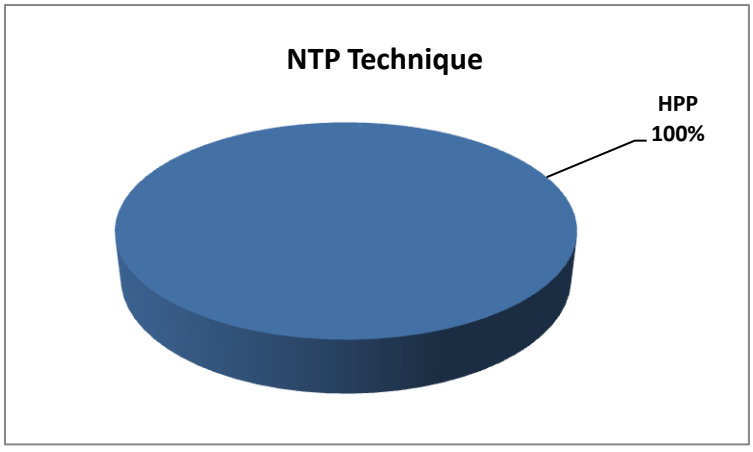
5. Patent Portfolio Analysis

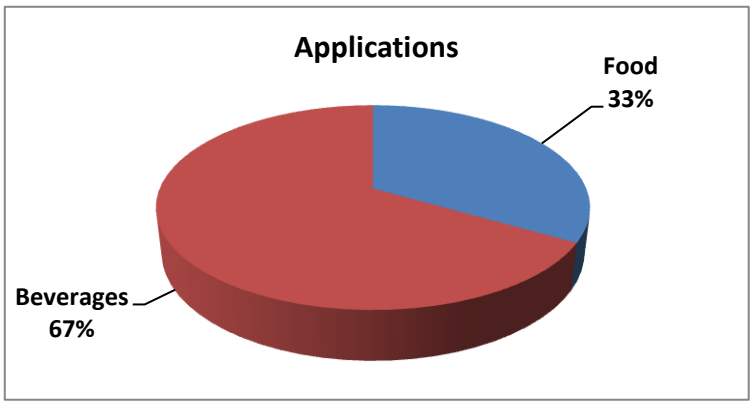
5.1 Patent Portfolio Analysis – Chic Group Co Ltd

Company Profile

Chic Foods Co Ltd is a leading global fruit processing company involved in processing and distributing fruit juice can products. The Company produces orange cans, yellow peaches cans, pineapple cans, and other products.







For sources of information, please refer to **Appendix A**

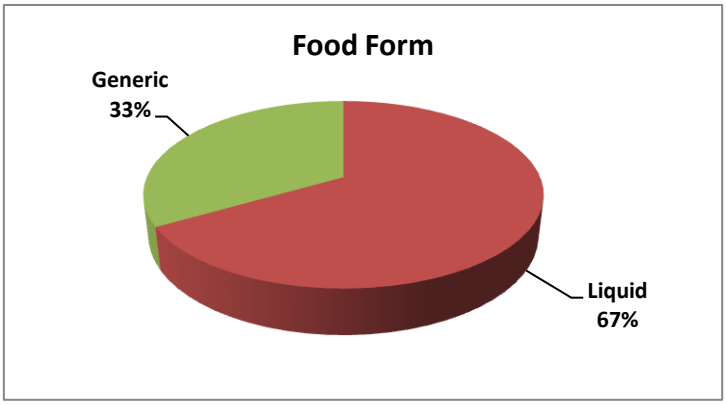
5.1.1 Key Patents – Chic Group Co Ltd

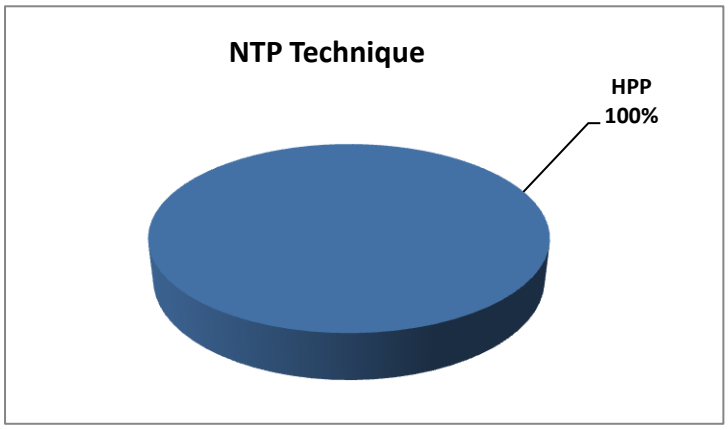
Patent No.	Key Features
CN104026504A	The patent application relates to sterilization of apple juice with high hydrostatic pressure treatment.
US20150351442A1	The patent application relates to high pressure pasteurization of milk, apple juice, coconut water, coconut milk, orange juice and/or carrot juice. Vegetative cells of harmful microorganisms and enzymes are inactivated by applying high pressure while maintaining the activity of the probiotics.

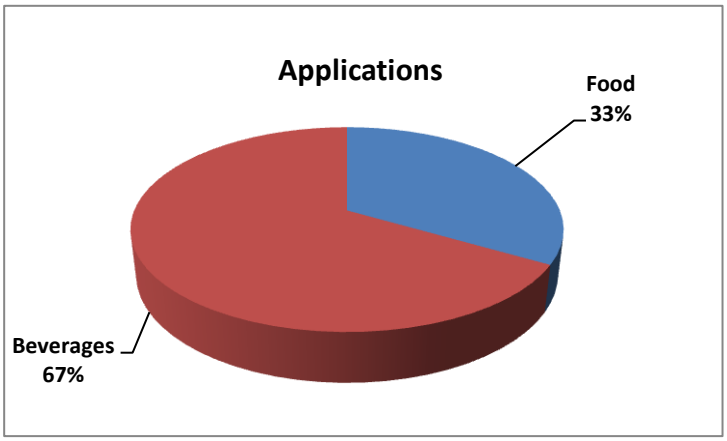
5.2 Patent Portfolio Analysis – Starbucks Corp

Company Profile

Starbucks Corp is a leading coffee retailer and offers a choice of coffee and tea beverages, coffee and tea related products, including a range of single-serve and ready-to-drink coffee and tea products, baked dairy products, juices and bottled water. Starbucks stores also offer an assortment of fresh food and snacks.





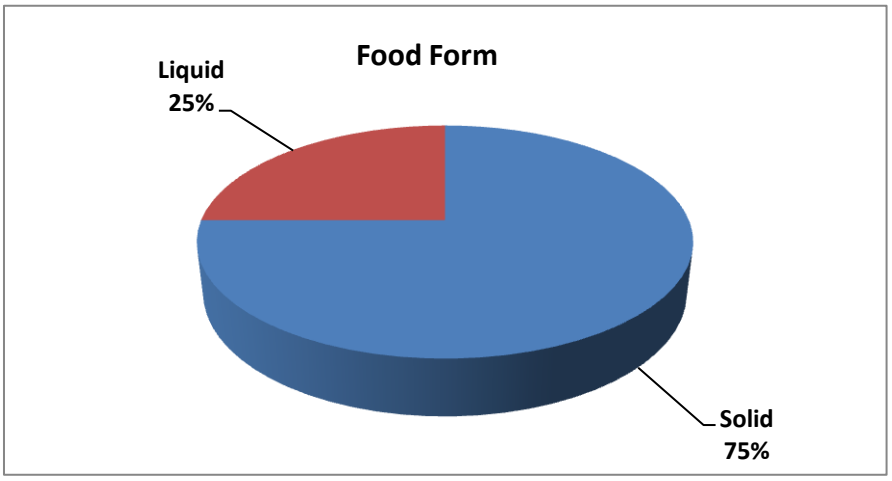


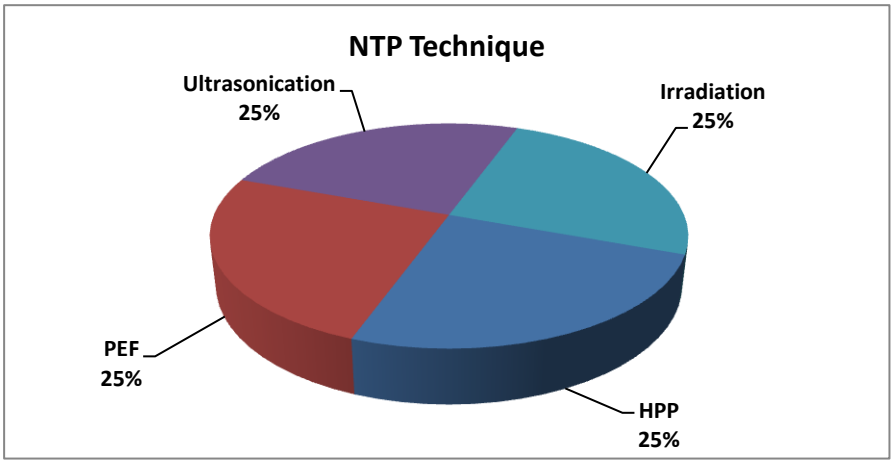
For sources of information, please refer to **Appendix A**

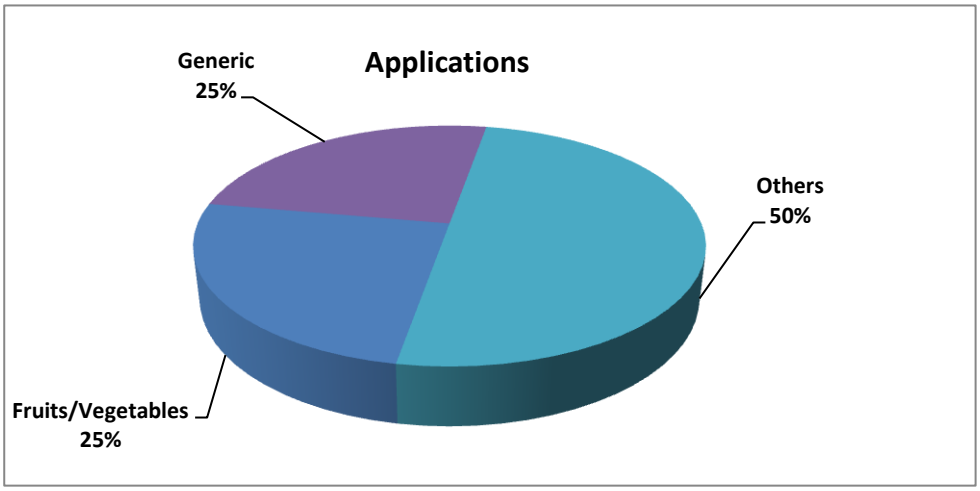
5.2.1 Key Patents – Starbucks Corp

Patent No.	Key Features
US9277763B2	The patent document relates to high pressure processing of inoculated low acid content food product for controlling the growth of pathogenic microorganisms
EP2654441A1	The patent application relates to method of sterilization of dairy beverages product using high pressure processing at low temperatures

5.3 Patent Portfolio Analysis – University of Jiangnan







For sources of information, please refer to **Appendix A**

5.3.1 Key Patents – University of Jiangnan

Patent No.	Key Features
CN105580976B	The patent document relates to non-thermal processing of rice protein using electron beam irradiation. Dispersion of solid rice gluten in water is irradiated in combination with alkali extraction then spray dried to get the rice protein.
CN102389148A	The patent application relates to food processing technology where the food is treated by a pulsed electric field with cold shock for a certain time to kill HPEF central microorganisms thereby prolonging a shelf life of food materials. After treatment the food is placed in a normal temperature environment, greatly extend the high-voltage pulsed electric field treated food shelf life at room temperature.

6. Analysis of Key Granted Patents/Patent Applications Assigned to Educational Institutes & Other Companies

6.1 Granted Patents/Patent Applications – Other Universities & Companies

Patent No.	Key Features
KR20180128577A Seoul Women's University	The patent application relates to an apparatus for sterilizing powdered food in a non-heated manner with simultaneous treatment of cold plasma and strong pulsed light. The process is effective to remove the food poisoning bacteria which are difficult to kill by other methods without causing quality deterioration.
CN105685296A South China Agricultural University	The patent application relates to a treatment method of tea beverages with uv irradiation for removing imidacloprid residues. The method is simple and easy to implement and low in cost, has a significant effect on reducing imidacloprid residues in a tea beverage and guaranteeing food safety.
US9440795B2 Teo Inc.	The patent document relates to a method of food pasteurization of prepackaged food using microwave irradiation. The invention also discloses an apparatus having the facility of microwave irradiation for pasteurizing or sterilizing the pre packed foods.

7. Appendix

7.1 Appendix A: Sources

- Non-thermal food pasteurization processes: an introduction
- Non-thermal processing in food applications: A review
- https://www.techsciresearch.com/news/2981-is-non-thermal-pasteurization-going-to-be-the-next-revolutionizing-trend-for-f-b-industry.html
- Ultra sonication: An Advanced Technology for Food Preservation
- Irradiation Pasteurization of Solid Foods: Taking Food Safety to the Next Level
- Dense Phase Carbon Dioxide Research: Current Focus and Directions
- Use of Atmospheric Pressure Cold Plasma for Meat Industry
- Microwave Heat treatment for Milk Processing
- Microwave food processing – a review
- Nonthermal Processing
- https://www.marketsandmarkets.com/Market-Reports/non-thermal-pasteurization-market-119569840.html?gclid=EAIaIQobChMI7rKrqta25AIVzhwrCh2ErQ-rEAAYASAAEgJ_yfD_BwE
- https://www.valuemarketresearch.com/report/non-thermal-pasteurization-market
- https://www.techsciresearch.com/report/global-non-thermal-pasteurization-market/1310.html
- https://www.prnewswire.com/news-releases/non-thermal-pasteurization-market-worth-2-7-billion-by-2023-exclusive-report-by-marketsandmarkets-tm--828189382.html
- http://www.chiic.com/en/ourdivisions.php
- https://www.starbucks.com/about-us/company-information/starbucks-company-profile

7.2 Appendix B: IPC Definitions

IPC	Definition
A23B	**PRESERVING, e.g. BY CANNING, MEAT, FISH, EGGS, FRUIT, VEGETABLES, EDIBLE SEEDS; CHEMICAL RIPENING OF FRUIT OR VEGETABLES; THE PRESERVED, RIPENED, OR CANNED PRODUCTS**
A23B 04/00	General methods for preserving meat, sausages, fish or fish products
A23B 4/22	Microorganisms; Enzymes
A23B 7/00	Preservation or chemical ripening of fruit or vegetables
A23B 7/10	Preserving with acids; Acid fermentation
A23C	**DAIRY PRODUCTS, e.g. MILK, BUTTER, CHEESE; MILK OR CHEESE SUBSTITUTES; MAKING THEREOF**
A23L	**FOODS, FOODSTUFFS, OR NON-ALCOHOLIC BEVERAGES; THEIR PREPARATION OR TREATMENT, e.g. COOKING, MODIFICATION OF NUTRITIVE QUALITIES, PHYSICAL TREATMENT**
A23L 2/00	Non-alcoholic beverages; Dry compositions or concentrates therefor; Their preparation
A23L 2/02	containing fruit or vegetable juices
A23L 3/00	Preservation of foods or foodstuffs, in general, e.g. pasteurising, sterilising, specially adapted for foods or foodstuffs
A23L 3/015	by treatment with pressure variation, shock, acceleration or shear stress
A23L 3/32	by treatment with electric currents without heating effect
A23L 5/00	Preparation or treatment of foods or foodstuffs, in general; Food or foodstuffs obtained thereby; Materials therefor
A23L 5/30	Physical treatment, e.g. electrical or magnetic means, wave energy or irradiation
B65B	**MACHINES, APPARATUS OR DEVICES FOR, OR METHODS OF, PACKAGING ARTICLES OR MATERIALS; UNPACKING**
A21D	**TREATMENT, e.g. PRESERVATION, OF FLOUR OR DOUGH FOR BAKING, e.g. BY ADDITION OF MATERIALS; BAKING; BAKERY PRODUCTS; PRESERVATION THEREOF**

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Contact Person

Tarun Khurana

iiprd@iiprd.com, info@khuranaandkhurana.com

Contact No.: +91-120-4296878, 2399113, 2399010

Contact Details

Noida (NCR) Office – Head Office

E-13, UPSIDC Site – IV, Behind Grand Venice, Greater Noida, 201308

Visit us at

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