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Señor

SUPERINTENDENTE DE INDUSTRIA Y COMERCIO

DIVISIÓN DE NUEVAS CREACIONES

E.

S.

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO



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Re: PI.-UNILEVER N.V.-Solicitud de Patente de Invención para
"CONCENTRADOS EMPACADOS EN LA FORMA DE UN GEL QUE
COMPRENDE ALMIDÓN MODIFICADO".-Clase A23L 1/0522.-
Expediente número 08-019.270-

Yo, **ALICIA LLOREDA RICAURTE**, mayor de edad, vecina de ésta ciudad, abogada titulada e identificada con la cédula de ciudadanía número 39.690.713 de Usaquén, Representante Legal en Bogotá para todos los asuntos relativos a la Propiedad Industrial de la sociedad **UNILEVER N.V.**, atentamente manifiesto a usted que interpongo **RECURSO DE REPOSICIÓN** contra la Resolución Número **55960** dictada por el señor Superintendente de Industria y Comercio, el 26 de septiembre de 2012, por medio del cual se niega el privilegio de patente para la invención contenida en el expediente de la referencia, con base en los siguientes:

I. FUNDAMENTOS DE DERECHO

Como fundamento de mi Recurso me permito manifestar ante ese Despacho que el contenido de la Resolución Número **55960** evidencia que durante el examen técnico realizado a la solicitud denegada de ninguna manera se consideraron de manera correcta las características, el objeto e importancia de la invención allí reclamada en su verdadera dimensión.

Es así que, a pesar de las modificaciones y argumentos proporcionados por el solicitante en el memorial de fecha 28 de Agosto de 2012 que se presentó como respuesta al Oficio Número 08708 que fue notificado por fijación en lista de fecha 30 de Mayo de 2012, en la Resolución impugnada ese Despacho mantiene las objeciones frente al Nivel Inventivo de la invención.

En vista de lo anterior, a continuación me permito exponer una limitación que ahora se realiza al capítulo reivindicatorio de la solicitud denegada por medio de la cual se restringe la materia reclamada por la misma a las realizaciones más preferidas de la invención. En este mismo sentido me permito manifestar que dicha modificación ahora realizada al capítulo reivindicatorio tiene como único fin exponer de manera aún más clara las características técnicas inventivas de la materia objeto de la solicitud en cuestión.

Asimismo, me permito brindar argumentos técnicos que demostrarán que el análisis realizado frente al arte previo es incorrecto y por lo tanto que la presente invención si cumple con el requisito exigido por el Artículo 18 de la Decisión 486, poniendo así de manifiesto que la presente solicitud es merecedora del privilegio de patente.

1. Modificaciones al Capítulo Reivindicatorio de la presente solicitud.

Teniendo como fundamento la facultad que la Decisión Andina 486 otorga al solicitante mediante las disposiciones del Artículo 34 de la misma, el cual establece:

"Artículo 34.- El solicitante de una patente podrá pedir que se modifique la solicitud en cualquier momento del trámite. La modificación no podrá implicar una ampliación de la protección que correspondería a la divulgación contenida en la solicitud inicial.

Del mismo modo, se podrá pedir la corrección de cualquier error material" (énfasis añadido).

A continuación, de la manera mas atenta me permito presentar ante ese Despacho un capítulo reivindicatorio **que ha sido modificado** de forma tal que limita la protección buscada únicamente para aquella materia que corresponde a las realizaciones preferidas de la invención que están contenidas en la descripción presentada para la solicitud.

En relación con el mencionado capítulo reivindicatorio modificado, me permito dirigir la atención de esa Oficina al hecho que la reivindicación 1 actualmente presentada ha sido limitada incluyendo la frase *"y en donde adicionalmente el concentrado está en forma de un gel"* con lo cual el concentrado empacado reclamado queda claramente limitado a aquel que además de tener la composición mencionada en la reivindicación 1 actualmente presentada tiene también la característica de estar en forma de un gel.

Del mismo modo, la reivindicación 11 actualmente presentada ha sido limitada incluyendo la frase *"y en donde adicionalmente el concentrado está en forma de un gel"* con lo cual el proceso reclamado queda delimitado coherentemente a aquel que permite obtener el concentrado empacado que está en forma de un gel que es objeto de la reivindicación 1 ahora modificada.

Sustento para estas modificaciones se encuentra a lo largo del texto de la descripción de la solicitud actualmente presentado, por ejemplo en las páginas 3 a 6 y 8-10.

Como consecuencia de lo anterior, el capítulo reivindicatorio modificado queda constituido por **15 reivindicaciones** que tienen como base las reivindicaciones actualmente presentadas y el texto de la descripción de la solicitud, en las cuales se ha

restringido la materia reclamada a las realizaciones más preferidas de la invención en virtud de las modificaciones expuestas anteriormente.

2. Argumentos que demuestran el Nivel Inventivo de la invención denegada de acuerdo con lo establecido en el Artículo 18 de la Decisión Andina 486 de 2000.

Por otro lado, en relación con el Nivel Inventivo de la presente solicitud me permito manifestar que ese Despacho no repara en los argumentos presentados en mi memorial de 28 de Agosto de 2012, los cuales establecen de forma incontrovertible el Nivel Inventivo que conlleva la solicitud denegada frente al estado del arte más próximo, y por lo tanto ese Despacho afirma en la Resolución impugnada que los documentos **WO 2004049822 (D1)**, **US 5291877 (D2)** y **US 6391358 (D3)** afectan la altura inventiva de la solicitud presentada a la luz de los siguiente argumentos.

En primer lugar ese Despacho afirma que *"La diferencia del documento D1 con la presente solicitud de patente radica en que D1 no divulga específicamente la selección específica de componentes, o lo que es lo mismo no divulga específicamente un concentrado que comprenda un almidón modificado en esas proporciones de combinación."*

Sumado a lo anterior esa Oficina señala que *"El efecto que logra el definir específicamente un concentrado que comprende un almidón modificado en una proporción específica es que se logra una reología de gel, y que además dicho gel tiene una buena estabilidad aun en altas concentraciones de sal."*

Sin embargo, el Examinador técnico sostiene que el uso de almidones modificados para preparar formulaciones alimenticias con reología de gel ya habían sido reportadas y para tales efectos señala los documentos D2 y D3.

Con relación a D2 el Examinador técnico sostiene que este documento *"divulga un gel alimenticio que requiere almidón gelificado modificado químicamente por complejación con un agente emulsionante (resumen). Dicho gel incluye componentes de sabor en estado líquido, como por ejemplo leche."*

Respecto al documento D3 ese Despacho afirma que *"divulga una composición espesante multi-etapa (resumen y reivindicaciones), que contiene salsa o gelatina en la cual se incluye una composición de gel multietapa que contiene dos agentes gelificante que espesan a diferentes tiempos en el proceso de empacado y entre los cuales se sugiere el uso de almidón como agente gelificante en composiciones acuosas (columnas 6 y 11)."*

Por lo tanto, concluye ese Despacho que *"la persona del oficio normalmente versada en la materia dispone de todas las enseñanzas necesarias en el estado del arte citado para formular un concentrado alimenticio que incluya un almidón modificado como en D2 o D3 en una composición de concentrado alimenticio como la conocida desde D1, para llegar así al objeto de la reivindicación 1 de la solicitud. Por lo cual se considera obvia."*

Más aún, el Examinador técnico sostiene que *"Como quiera que sea el concentrado de interés se deriva de manera evidente del arte previo, no provoca ningún efecto técnico inesperado o sorprendente que pueda entenderse como un salto cualitativo en la técnica y no tiene nivel inventivo."*

Sobre estos señalamientos, me permito dirigir la atención de ese Despacho a las siguientes consideraciones y argumentos técnicos por medio de los cuales será completamente evidente que los documentos citados, ni por si mismos ni en combinación, contienen alguna sugerencia o evidencia técnica que haya podido servir de guía o motivación a la persona versada en la materia para alcanzar de forma obvia o evidente la materia de las reivindicaciones de la presente solicitud, o la soluciona dada por la misma al problema técnico encontrado, lo que permite afirmar sin lugar a dudas que la materia revelada en la invención denegada, es merecedora del privilegio de patente solicitado ya que, contrario a la posición de esa Oficina, dicha materia sí cumple con el requisito de Nivel Inventivo tal como es exigido en el Artículo 18 de la Decisión 486 de 2000, como me permito demostrar a continuación.

2.1. **Antecedentes de la invención**

Para comenzar, me permito dirigir la atención de esa Oficina al hecho que en virtud de las modificaciones realizadas al capítulo reivindicatorio, expuestas anteriormente, la materia ahora reclamada por la presente solicitud se refiere a un concentrado de alimento en forma de un gel.

En conexión con lo anterior, me permito señalar que los productos listos para consumir en forma de geles, como pudines, ya eran bien conocidos para el momento del desarrollo de la presente invención. Sin embargo, los productos concentrados con un alto contenido de sal solo estaban presentes en ese momento en forma seca (cubos de caldo) o en forma líquida, pero los concentrados de alimento con alto contenido de sal **en la forma de un gel** no eran conocidos.

A este respecto, el solicitante desea señalar que la razón para que no existiera un concentrado de alimento con un alto contenido de sal en forma de un gel, era que no se conocía cuál agente gelificante debía usarse para tal fin dado que varios agentes gelificantes no forman un gel en condiciones de altos contenidos de sal o producen complicaciones serias.

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Frente a este problema técnico Unilever encontró que un numero limitado de agentes gelificantes, que como tal fueron conocidos como agentes gelificantes, de manera sorprendente podían proporcionar un gel en condiciones de alto contenido de sal (15-40% con base en el contenido de agua). Por este desarrollo técnico se hizo posible proporcionar un concentrado de alimento que tiene un alto contenido de sal el cual estuviera en forma de un gel.

Así las cosas, la presente solicitud de patente reclama un concentrado de alimento en la forma de un gel, en donde se utiliza almidón modificado como el agente gelificante, el cual es estable bajo condiciones de salinidad extremadamente altas.

Sumado a lo anterior, me permito señalar que un beneficio adicional de utilizar almidón modificado como agente gelificante es que este agente mostró una cantidad reducida de sinéresis (en otras palabras una cantidad pequeña de agua expulsada del gel), un fenómeno que puede ser especialmente problemático a altos contenidos de sal.

Por lo tanto, después de este avance técnico de como preparar concentrados de alimento con altos contenidos de sal en forma de un gel, este tipo de productos se ha convertido en un producto de consumo nuevo y popular en el mercado.

2.2. La elección de D1 como el estado del arte más cercano a la presente invención demuestra las suposiciones erradas hechas por el Examinador Técnico sobre D1 y sugiere que se ha realizado un análisis hindsight o "Ex post facto" al utilizar las enseñanzas de dicho documento del estado del arte.

El Examinador Técnico indica que el documento D1 es uno de los documentos que comprenden el estado del arte más cercano a la presente invención dado que se relaciona a un concentrado de alimento (mismo campo técnico) y que comparte varias características del concentrado de la reivindicación 1 de la presente solicitud.

A este respecto me permito señalar de manera respetuosa que el Examinador Técnico parece haber pasado por alto que las enseñanzas del documento D1 son opuestas a aquellas de la presente solicitud. De hecho, D1 y la invención denegada tienen objetivos diferentes pues la solicitud denegada busca proporcionar un producto con una textura de gel a pesar de los altos contenidos de sal del producto, y además busca un nivel bajo de sinéresis del gel mientras que el objetivo completo de D1 es mantener una textura líquida.

En conexión con lo anterior, **es necesario llamar la atención sobre el hecho que el ingrediente principal de la presente invención, es decir el almidón modificado, debe ser activo (gelatinizado, hinchado) para proporcionar la pretendida textura de gel, mientras que en D1 cualquier almidón modificado debe estar en su forma inactiva para no destruir el producto líquido deseado de**

D1 pues en el caso en que el almidón en D1 sea hinchado (es decir activo) aparecen varios problemas para la composición como se muestra claramente en la líneas 14 a 18 de la página 5 de D1 en donde se señalan problemas relacionados con la fluidez, la porosidad, la manipulación y la conveniencia de la composición obtenida si se utilizara un almidón hinchado (activo).

Así las cosas me permito señalar una vez más que el objetivo completo de D1 es mantener una la textura líquida y evitar una textura sólida (como por ejemplo la de gel) razón por la cual el almidón en D1 debe ser un almidón inactivo ("para prevenir una consistencia espesa que podría evitar la fluidez"). **Por lo tanto, es claro que el documento D1 conduce a la persona versada en la materia lejos de la solución proporcionada por la presente solicitud.**

Sumado a lo anterior, me permito manifestar que D1 es totalmente silencioso sobre el objetivo adicional de la presente solicitud que es proporcionar un gel en donde la sinéresis esté ausente o sea al menos baja (página 4 de la presente solicitud).

Adicionalmente, contrario a la opinión del Examinador Técnico, me permito dirigir la atención de esa Oficina al hecho que lo revelado en D1 no es un producto a base de almidón toda vez que el almidón de D1 debe estar en la forma inactiva. En cambio, D1 es un producto a base de xanthan ya que la goma xanthan funciona como el texturizador en D1.

Por último, me permito manifestar que la elección del documento D1 como uno de los documentos del estado del arte más cercano a la presente invención también sugiere un análisis en retrospectiva de sus enseñanzas toda vez que se ignoran las revelaciones explícitas de D1 que conducen a la persona medianamente versada en la materia lejos de la presente solicitud y se ignora también que D1 no revela "productos a base de almidón". Así, conociendo de antemano la solución proporcionada por la presente solicitud el Examinador técnico asegura que en D1 se encuentran características que se solaparían con las de la presente solicitud y que sería obvio el uso de almidón modificado como el agente gelificante estable en productos de alto contenido de sal.

En vista de lo anterior es claro que el documento D1 no puede ser considerado como uno de los documentos que hacen parte del estado del arte más cercano a la presente solicitud debido a que para calificar a un documento como el estado del arte más cercano a una invención las enseñanzas de dicho documento no deben ser opuestas a las de la invención en cuestión, como ocurre en el presente caso en donde (tal como se expuso anteriormente) las enseñanzas de D1 conducen a la persona medianamente versada en la materia lejos de la solicitud denegada pues:

- D1 y la presente solicitud tienen diferentes objetivos, D1 busca obtener un producto líquido mientras que la invención denegada se refiere a un producto en gel;
- D1 es silencioso sobre el objetivo adicional de la presente solicitud que es un producto en gel en donde adicionalmente haya ausencia de o baja sinéresis;
- en D1 se enseña explícitamente que el ingrediente principal del producto de la presente invención (almidón modificado) debe estar inactivo para mantener la forma fluida del producto de D1 (véase la línea 15 de la página 5 de D1).

Además, el hecho que el Examinador técnico haya ignorado los objetivos opuestos y enseñanzas opuestas entre el documento D1 y la presente solicitud pone de manifiesto el análisis en retrospectiva que fue realizado a D1 para obtener la materia de la presente solicitud.

2.3. Partiendo del documento D1, la persona medianamente versada en la materia no llegaría de manera obvia a la presente invención

A pesar de haber quedado claramente establecido que el documento D1 no puede ser considerado como uno de los documentos que comprenden el estado del arte más cercano a la presente invención, en gracia de discusión me permito exponer a continuación como a partir de las enseñanzas de D1 la persona medianamente versada en la materia no lograría llegar de manera obvia o evidente a la materia objeto de la presente solicitud.

(i) El Examinador técnico no define un punto de partida en D1

A este respecto me permito señalar que el Examinador técnico no indica una composición en D1 que pudiera funcionar como un punto de partida normal para la persona medianamente versada en la materia.

En vez de esto, el Examinador técnico se refiere a características individuales de D1, combinándolas y creando un punto de partida hipotético. Por ejemplo, el Examinador técnico combina las enseñanzas de las líneas 10 a 13 de la página 5 de D1 (el uso opcional de almidón modificado) con la enseñanza de las páginas 7 y 8 de dicho documento en donde se mencionan los rangos de los ingredientes y se muestra un rango de 0% a 20% de sal, un rango de 10 a 55% de agua y de 10 a 50% de almidón. Con base en lo anterior el Examinador concluye que los rangos de cada ingrediente de la composición de D1 se solapan con los de la presente solicitud, infiriendo en consecuencia que D1 revelaría una composición con un alto contenido de sal (15-40% de agua) que comprende almidón modificado. Así, a la vista del Examinador técnico solo los rangos del almidón modificado quedarían por ser definidos. Sin embargo, la persona versada en la materia reconocerá que esta no es la manera como una persona medianamente versada

en la materia realizaría su análisis del documento D1. Así las cosas, resulta obvio que el Examinador técnico ha creado su propio punto de partida.

En relación a lo anterior, me permito manifestar que no es correcto afirmar que todos los rangos de los componentes del producto de D1 se solapan con los del producto de la presente solicitud ya que D1 revela todas las posibles combinaciones que pueden ser hechas con su información pero como es bien sabido para la persona versada en la materia una combinación que se realice con los valores extremos de dichos rangos (por ejemplo con el menor contenido de agua y el mayor contenido de almidón) no funciona para obtener el producto objetivo de D1. A este respecto me permito señalar que normalmente estos rangos deben ser leídos e interpretados en el contexto de la descripción de los documentos que para el caso de D1, por ejemplo, se menciona que "con la condición de que se mantenga una textura líquida".

Pero más relevante aún, es el hecho que estos rangos de D1 no revelan de manera directa y sin ambigüedad solo una composición que pudiera ser hipotéticamente realizada, razón por la cual el único lugar en donde la persona medianamente versada en la materia puede encontrar un punto de partida real es en los Ejemplos específicos revelados en D1 los cuales se analizará a continuación.

(ii) Definiendo los Ejemplos 2 y 3 de D1 como punto de partida, partiendo del problema técnico de la presente solicitud

En vista de que el problema técnico de la presente solicitud es ¿Cómo proporcionar una textura de gel en una composición que comprende de 15% a 40% de sal con base en el contenido de agua, el punto de partida natural para la persona medianamente versada en la materia sería una composición que tenga 15% a 40% de sal con base en el contenido de agua.

En conexión con lo anterior, las únicas composiciones en D1 que revelan tal contenido de sal son los Ejemplos 2 y 3 de D1. Estas composiciones comprenden de manera respectiva 16.1% y 25.8% de sal con base en el contenido de agua. Sin embargo D1 señala que estas composiciones comprenden Cremalys 516 como almidón, el cual es almidón nativo de papa y no almidón modificado.

(iii) Definiendo los Ejemplo 5 de D1 como punto de partida, partiendo de la solución de la presente solicitud

En contraste con lo anterior, cuando se sigue el razonamiento del Examinador técnico y se encuentra un punto de partida que revela la solución de la presente solicitud, independientemente del problema técnico de D1 e independientemente de la cantidad de los ingredientes y más aún beneficiándose del conocimiento previo que se tendría de la

solución lograda por la solicitud denegada, se encuentra que el Ejemplo 5 de D1 sería el estado del arte más cercano.

Dicho ejemplo de D1 revela el uso de Colflo67 como almidón, el cual es un almidón modificado. Sin embargo el nivel de sal de esta composición es de 14% con base en el contenido de agua, el cual es un rango menor que el rango reclamado por la solicitud denegada.

2.4. Diferencias entre el estado del arte más cercano comprendido en D1 y el concentrado objeto de la solicitud denegada

El estado del arte más cercano a la presente invención que se encuentra en el documento D1 son los Ejemplos 2,3 y 5 de D1.

Con relación a los Ejemplos 2 y 3 me permito señalar que estos se diferencian de la reivindicación 1 ahora modificada de la presente solicitud en que:

- Los productos obtenidos de los Ejemplos 2 y 3 de D1 no son un gel.
- Los Ejemplos 2 y 3 de D1 no comprenden un almidón modificado.
- Los Ejemplos 2 y 3 de D1 muestran niveles de almidón con base en el contenido de agua que se encuentran fuera del rango en el que se encuentra el almidón en el concentrado reclamado por la presente solicitud que es de 10-30% con base en el contenido de agua. Los Ejemplos 2 y 3 de D1 tienen de manera respectiva un contenido de almidón de 69% y de 79.3% con base en el contenido de agua.

Por otro lado, el Ejemplo 5 de D1 se diferencia de la reivindicación 1 ahora modificada de la presente solicitud en que:

- El producto del Ejemplo 5 no es un gel.
- El Ejemplo 5 muestra un contenido de sal que se encuentra fuera del rango reivindicado. El valor contenido de sal en el Ejemplo 5 es de 14% con base en el contenido de agua.
- El Ejemplo 5 muestra un contenido de almidón con base en el contenido de agua que se encuentra fuera del rango mencionado en la reivindicación 1 de la presente solicitud, que es de 10 a 30% con base en el contenido de agua, y en contraste con esto el Ejemplo 5 muestra un contenido de almidón modificado de 65.8% con base en el contenido de agua.

Sumado a todo lo anterior, me permito dirigir la atención de ese Despacho al hecho que solo el Ejemplo 3 de D1 contiene componentes que imparten sabor y es crema entera en un 16.2% y como se señala en D1 la crema proporciona sabor (línea 5, de la página 9 de D1). En contraste, el sorbitol, un poliol, presente en los Ejemplos 2, 3 y 5 no son

considerados como ingredientes que imparten sabor en D1 sino como agentes que disminuyen el agua (líneas 30-31 de la página 5 de D1).

2.5. Efecto de las Diferencias que caracterizan el concentrado de la presente solicitud

En este sentido, **en primer lugar me permito resaltar que el efecto que logra el almidón modificado en la proporción correcta es que el producto tiene la textura de gel ya mencionada a pesar que el concentrado tiene una cantidad de sal alta de 15-40% con base en el contenido de agua**, la cual puede ser dispersada o disuelta razonablemente rápido (líneas 31-34 de la página 5 de la descripción de la solicitud como se encuentra actualmente presentada).

Adicionalmente, **dicho almidón modificado en las proporciones que se muestran en la reivindicación 1 de la presente solicitud proporciona un gel que tiene una cantidad de sinéresis baja** (línea 15 de la página 2, línea 35 de la página 5 y la línea 6 de la página 9).

Sumado a lo anterior, **otro efecto obtenido en el producto por estar en forma de gel es que le permite ser dosificado fácilmente como una unidad.**

2.6. Problema Técnico Objetivo de la Solicitud denegada

El problema técnico objetivo de la presente solicitud puede ser formulado como: ¿Cómo proporcionar un concentrado de alimentado para preparar a un caldo, consomé, sopa, salsa, jugo de carne o para uso como un condimento que tiene un alto contenido de sal (15-40% con base en el contenido de agua) que es:

- un gel estable y
- que muestra un nivel de sinéresis bajo.

Con relación a lo anterior me permito resaltar que la ventaja adicional de un nivel bajo de sinéresis o ausencia de la misma ni siquiera fue considerada por el Examinador Técnico dentro de su análisis expuesto en la Resolución Número **55960**.

Ahora bien, aun cuando el Examinador Técnico formuló en la resolución antes mencionada un problema técnico objetivo comparable al anteriormente mencionado para la solicitud, de manera respetuosa me permitiré demostrar a continuación que las conclusiones a las que llega el Examinador no son correctas.

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2.7. A partir de las enseñanzas de D1 la persona medianamente versada en la materia no llegaría de manera obvia a la solución proporcionada por la presente solicitud al problema técnico identificado. D1, D2 y D3 son totalmente silenciosos sobre enseñanzas alrededor de la solución proporcionada por la presente invención.

Para comenzar, frente a la conclusión que realiza el Examinador técnico en cuanto a que:

"la persona del oficio normalmente versada en la materia dispone de todas las enseñanzas necesarias en el estado del arte citado para formular un concentrado alimenticio que incluya un almidón modificado como en D2 o D3 en una composición de concentrado alimenticio como la conocida desde D1, para llegar así al objeto de la reivindicación 1 de la solicitud."

Me permito señalar que dentro del campo de las patentes es un hecho reconocido que dentro de la evaluación del Nivel Inventivo de una solicitud la cuestión no es si la persona medianamente versada en la materia que partiera de las enseñanzas de uno o dos documentos podría llegar a la invención reclamada en vista del problema técnico objetivo, sino si dicha persona en efecto habría llegado allí de manera obvia a la solución obtenida por la solicitud en estudio.

Así las cosas, para llegar a la materia objeto de la presente solicitud el estado del arte debería al menos sugerirle a la persona medianamente versada en la materia cómo modificar las enseñanzas del documento D1 para llegar al concentrado de la presente solicitud. Sin embargo, a continuación me permito exponer argumentos que pondrán de manifiesto que ni D1, ni D2 ni D3 revelan enseñanzas que condujeran de manera obvia a dicha persona a la materia objeto de la presente solicitud.

(i) D1 es silencioso con respecto a una textura de gel o a cómo crear dicha textura de gel; no existe ningún señalamiento en D1 a este respecto pues este va dirigido a otro objetivo.

Partiendo de los puntos de partida concretos de D1, es decir los Ejemplos 2 y 3 de D1, la persona medianamente versada en la materia debería modificar un producto líquido con un contenido de sal de 15-30% con base en el contenido de agua a un producto con textura de gel.

En conexión con lo anterior, a fin de evitar un análisis en retrospectiva, el documento del arte debe sugerir a la persona medianamente versada en la materia la manera de cómo llegar al concentrado con textura de gel de la presente solicitud, pero a la luz de las revelaciones del documento D1 salta a la vista que dicho documento no muestra una sugerencia de cómo hacer dicho gel. De hecho, la palabra gel ni siquiera se

encuentra en el documento D1, así como también D1 tampoco indica al almidón como texturizador, y mucho menos al almidón modificado.

En efecto, D1 está lejos de enseñar el uso de almidón modificado como agente gelificante pues en dicha referencia el almidón se utiliza en su forma inactiva, de modo que este debe estar en el "estado no hinchado dado que una consistencia muy espesa podría impedir la fluidez optima" (véanse las líneas 14-18 de la página 5 de D1). Aun en este párrafo la formación de gel no es mencionada. Más bien, parece que la consecuencia de utilizar almidón en estado hinchado (activo) en la composición de D1 es una pasta espesa, pero sin embargo D1 no menciona un sólido con textura de gel.

Por lo tanto, estaría más en línea con las revelaciones del documento D1 que la persona medianamente versada en la materia se viera motivada a modificar el "agente espesante" (líneas 10-13 de la página 7 de D1) en vez del almidón, pues todas las composiciones de punto de partida revelan un 0.1% de goma xanthan y dicha goma ha sido descrita como relevante para la textura de los productos de D1.

(ii) D2 y D3 no proporcionan una sugerencia o motivación para utilizar almidón modificado, sin hablar del uso de almidón modificado para formar un gel que es estable en composiciones de alto contenido de sal y que muestren una sinéresis reducida.

En este sentido, el Examinador técnico a afirmado en la Resolución ahora impugnada que:

"Sin embargo, el uso de almidones modificados para preparar formulaciones alimenticias con reología de gel ya habían sido reportadas, por ejemplo en cualquiera de los D2 o D3."

Frente a esta afirmación me permito manifestar que la misma no resulta cierta tal como se establecerá a continuación. Para tales efectos me permito hacer primero una breve descripción de las enseñanzas de D2 y de D3.

Documento D2

Este documento enseña un proceso para proporcionar un gel (reivindicación 1). Dicho proceso utiliza almidón nativo (línea 31 de la columna 7) que contiene 15-30% de amilosa (líneas 36-37 de la columna 7). El proceso de D2 libera amilosa desde el almidón por calentamiento y la amilosa liberada es acomplejada con un emulsificante (líneas 36-38 de la columna 2). Así el producto resultante es amilosa enlazada a emulsificante, el cual es descrito como proporcionador de geles.

De manera específica me permito señalar que en D2 la cantidad de almidón utilizada en la reacción para proporcionar geles está en porcentajes pequeños, según las líneas 17-18 de la columna 2 y la línea 35 de la columna 7 de D2, entre un 1 a 5% de almidón nativo como material de partida en la reacción.

Consecuentemente, la persona versada en la materia reconocerá que la aplicación de las enseñanzas de D2 conduce a productos de bajo contenido de sal como pudines (véase la línea 63 de la columna 3) razón por la cual no se menciona la sal en D2.

En vista de lo anterior, me permito manifestar que no es correcta la afirmación realizada por el Examinador técnico en cuanto a que D2 revelaría "almidón modificado" pues a partir de la lectura atenta de dicho documento es claro que allí no se revela una modificación de almidón por acomplejamiento del almidón con dicho emulsificante, toda vez que la reacción de acomplejamiento que se lleva a cabo en D2 no conduce a lo que se entiende en el campo técnico como "almidón modificado".

A este respecto, me permito señalar que, por ejemplo, tal como se define en Wikipedia (herramienta virtual de libre acceso que contiene aspectos generales del estado del arte) define "almidones modificados" como "Almidones modificados, también llamados derivados de almidón, son preparados por tratamiento físico, enzimático o químico de almidón nativo, cambiando de este modo las propiedades del almidón" (véase http://en.wikipedia.org/wiki/Modified_starch).

Por lo tanto es claro que el documento D2 de ninguna manera produce un almidón modificado toda vez que el compuesto de amilosa (15-30% del almidón nativo inicial) es extractado o liberado del almidón para su acomplejamiento con el emulsificador produciendo así compuesto amilosa-emulsificador y no un almidón modificado (que sería un compuesto almidón-emulsificador).

Consecuentemente con respecto a D2 se puede concluir que:

- **No revela el uso de almidón modificado.**
- Revela un proceso para hacer un gel a partir de almidón nativo.
- Enseña que la cantidad de almidón nativo a ser utilizada en el proceso de reacción es muy baja (1 a 5%).
- Es totalmente silencioso sobre composiciones con altos contenidos de sal y sinéresis reducida.

Documento D3

Por su parte, el documento D3 describe un proceso para hacer un producto gelificado que comprende dos pasos: un paso de gelificado lento y un paso de gelificado rápido.

Dentro del documento D3 se sugieren muchos agentes gelificantes para estos pasos del proceso. Uno de los agentes gelificantes sugeridos es el almidón. Sin embargo, D3 es silencioso sobre el uso de almidón modificado.

Adicionalmente, los productos de D3 son composiciones alimenticias listas para comer y no concentrados (como el producto de la solicitud denegada).

Sumado a lo anterior, D3 no revela el uso de sal y mucho menos en concentraciones del 15-40% en peso con base en el contenido de agua (como se reclama en la reivindicación 1 de la solicitud en cuestión).

En consecuencia, con respecto al documento D3 se puede concluir que:

- **No revela el uso de almidón modificado.**
- No revela ninguna cantidad en donde el almidón sea utilizado como agente gelificante.
- No enseña nada sobre la aplicación en condiciones de altas concentraciones de sal.

Así las cosas, a la luz de las revelaciones anteriores salta a la vista que la afirmación realizada por el Examinador en cuanto a que D2 y D3 revelarían el uso de almidón modificado como agente gelificante no está soportada por ninguno de los documentos D2 o D3, y mucho menos D2 o D3 sugeriría el uso de almidón modificado como agente gelificante bajo condiciones de altas concentraciones de sal, ni el uso de almidón modificado como un agente gelificante para proporcionar un gel estable que muestre sinéresis baja.

(iii) Los comentarios adicionales del Examinador técnico con respecto a enseñanzas del estado de la técnica del uso de almidón modificado no son correctas o no son soportadas por documentos del estado del arte.

- Con relación a la afirmación realizada por el Examinador técnico en la resolución ahora impugnada en cuanto a que *"la selección de un aditivo gelificante de en este caso un almidón modificado no provoca ningún efecto técnico inesperado o sorprendente puesto que dichos almidones se utilizan justamente para tal fin, para que al ser formulados en una composición determinada se logre la reología deseada. Es bien conocido en el arte que los almidones modificados forman geles y que dichos geles resultan tener ciertas ventajas en cuanto a la estabilidad de sus propiedades incluso frente a factores químicos como cambios de pH y cambios en la concentración salina."*⁴

⁴ *Resistant starch a review of the physical properties and biological impact of RS3. S. G. Haralampu, Carbohydrate Polymers 41 (2000) 285-292."*

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Me permito señalar que esta afirmación no encuentra fundamento en el documento citado.

En este sentido, el documento de Haralampu citado por el Examinador técnico (y que se adjunta a este memorial) se refiere a almidón que es resistente a la degradación enzimática, pero dicho documento no contiene ninguna referencia a ventajas en cuando a la estabilidad de las propiedades del almidón a altas concentraciones de sal, y dicho documento mucho menos sugiere al almidón modificado para producir geles en concentraciones de sal del 15-40% con base en el peso de agua (como los que son objeto de la reivindicación 1 modificada de la presente solicitud).

Además, el documento de Haralampu también es totalmente silencioso sobre la reducción de la sinéresis como una consecuencia del uso de almidón modificado bajo condiciones de altas concentraciones de sal.

Así las cosas, queda claramente establecido que la afirmación que realizó el Examinador técnico, antes mencionada, no goza de soporte en el documento del estado del arte mencionado y es simplemente incorrecta.

- Además, el Examinador técnico señala que el Flojel70 corresponde a un almidón de maíz modificado *"que se comercializa justamente para lograr el efecto que aquí se argumenta como inesperado o sorprendente, la obtención de un concentrado en forma de gel que tiene las propiedades reológicas requeridas y que es estable aun en altas concentraciones de sal."*

Frente a esta afirmación me permito manifestar que el solicitante no es consciente de este hecho, sin embargo este comentario del Examinador debe ser soportado por evidencia clara antes de que sea tomado en cuenta en la argumentación, toda vez que hasta este momento el Examinador técnico ha fallado en proporcionar alguna evidencia que soporte este comentario.

- Por otro lado, el Examinador técnico sostiene que *"las sales, por ejemplo los cloruros, son agente espesantes comúnmente utilizados en la industria de alimentos"* y como soporte a esta afirmación señala el documento Specialty starches for snack foods, M. G. Sajilata, R. S. Singhal, Carbohydrate Polymers, 59 (2005) 131-151.

Con relación a lo anterior, la persona versada en la materia reconocerá que la afirmación del Examinador de que *"las sales, por ejemplo los cloruros, son agentes espesantes..."* (Resaltado fuera de texto) resulta extraña en si misma, pues dentro de los conocimientos básicos de una persona medianamente versada en la materia no se encuentra que las sales actúen como agentes espesantes, razón por la cual

frente a esta afirmación surgen preguntas como por ejemplo ¿Cómo puede un anión cloruro espesar una composición?

Ahora bien, el Examinador ha señalado el documento de Sajilata y Singhal como un documento que soportaría tal afirmación realizada, el cual comprendería el conocimiento que a este respecto tiene cualquier persona medianamente versada en la materia. Sin embargo, la persona versada en la materia reconocerá de la lectura atenta de dicho documento que la afirmación de que "las sales sean agentes espesantes" no encuentra ningún sustento en dicha referencia.

Por lo tanto, dado que esta afirmación del Examinador técnico no se encuentra soportada debe ser en consecuencia eliminada de su argumentación.

Adicionalmente, en gracia de discusión me permito señalar que de la lectura detallada del documento de Sajilata y Singhal resultará claro para la persona versada en la materia que esta referencia tampoco contiene alguna referencia sobre el uso de almidón modificado en geles con altas concentraciones de sal.

(iv) Conclusiones

Como resultado de los argumentos anteriormente expuesto se puede concluir lo siguiente:

- De la información de los documentos D1, D2 y D3 no existe ninguna enseñanza o sugerencia que motivara a la persona medianamente versada en la materia a que el almidón modificado sería adecuado para proporcionar una textura de gel a un concentrado con altas concentraciones de sal de 15-40% en peso con base en el contenido de agua, y mucho menos a que el uso de dicho almidón modificado produciría una textura de gel con una sinéresis reducida. De hecho tal como se expuso anteriormente los documentos D2 y D3 ni siquiera mencionan el uso de almidón modificado en la materia allí revelada.
- Con base en lo anterior resulta evidente que la persona medianamente versada en la materia no encontraría ninguna motivación en el estado del arte comprendido en D1, D2 y D3 para utilizar almidón modificado como un agente gelificante.
- Partiendo de los Ejemplos 2 y 3 del documento D1 la persona medianamente versada en la materia no encontraría ninguna enseñanza en el estado del arte de que el almidón modificado debiera ser utilizado como un agente gelificante y que para tal fin el almidón nativo debiera ser intercambiado por almidón modificado, es decir que debiera ser transformado en su forma gelatinizada (activa).

- Partiendo del Ejemplo 5 del documento D1 la persona medianamente versada en la materia no encontraría ninguna enseñanza en el estado del arte de que Colflo67 (almidón modificado) debiera ser utilizado como agente gelificante y que para tal fin debiera ser transformado en su forma gelatinizada (activa).
- Por lo tanto, para solucionar el problema técnico objetivo de la presente solicitud la persona medianamente versada en la materia tal vez podría llegar a la solución de utilizar almidón modificado, pero en la ausencia de alguna enseñanza a este respecto en el estado del arte citado por el Examinador, no existiría una expectativa medianamente razonable de que dicha persona haría esto y de cómo dicha persona lo haría.

(v) Aun cuando fuera utilizado almidón modificado como agente gelificante, la persona medianamente versada en la materia no llegaría a la presente invención.

En gracia de discusión me permito señalar que aún en el caso en que la persona medianamente versada en la materia, pese a no existir alguna enseñanza en el estado del arte comprendido por D1, D2 y D3 e ignorar las enseñanzas de D1 que van en contra de las de la presente solicitud, usara el almidón modificado como un agente gelificante en el producto de D1, dicha persona no obtendría una textura de gel para el producto obtenido debido a las siguientes razones:

- Los puntos de partida indicados por los Ejemplos 2, 3, o incluso el Ejemplo 5, muestran una concentración muy elevada de almidón que respectivamente son de 69%, 79.3% y 65.8% en peso con base en el contenido de agua.

Es claro que no existe ninguna enseñanza en el estado del arte de que una concentración de almidón modificado en el rango de 15-40% en peso con base en el contenido de agua deba ser utilizada para conseguir un concentrado sólido con textura de gel y en donde el nivel de sinéresis en el gel sea bajo o incluso esté ausente.

Así las cosas, para obtener la presente solicitud a partir de las enseñanzas de los documentos D1, D2 y D3 la persona medianamente versada en la materia no solo necesitaría de un conocimiento previo de que el almidón modificado produce tales efectos técnicos antes mencionados, sino que también debería iniciar una aproximación por ensayo y error para encontrar la cantidad correcta de almidón modificado que permite obtener tales características técnicas del producto, y que tal como lo reclama la reivindicación 1 ahora modificada de la presente solicitud la proporción de almidón modificado que permite tales resultados es de 15-40% en peso con base en el contenido de agua.

- Además, el almidón modificado de D1 se encuentra en la forma inactiva así que en el caso en que la persona medianamente versada en la materia lograra establecer la cantidad correcta a utilizar de almidón, este no tendría ningún efecto pues el almidón en su forma inactiva no forma ningún gel y por lo tanto no se obtendría ninguna textura de gel en el producto obtenido toda vez que para lograr esta característica el almidón modificado debe ser un agente gelificante, es decir debe estar en su forma activa.

(vi) La tecnología de D1 es incompatible con la presente invención

Sumado a todo lo anterior, me permito también manifestar que debido a que el documento D1 enseña un proceso de producción en donde el almidón modificado esta presente en su forma inactiva, tal como se expuso anteriormente, para que a partir de las revelaciones de este documento pudiera obtenerse la materia reclamada por la presente solicitud una de las modificaciones principales a realizar sería activar dicho almidón para que funcionara como un agente gelificante.

Para tal fin, el proceso de producción mostrado en D1 debe ser modificado. Sin embargo dado que no existe ninguna enseñanza dentro del estado del arte de como modificar de manera particular dicho proceso, la modificación en sí implicaría un proceso de ensayo y error.

Por lo tanto, en resumen me permito señalar que a partir de las enseñanzas de D1 se deben hacer varias elecciones a fin de intentar llegar a la materia objeto de la presente solicitud, las cuales incluyen:

- Mediante un análisis en retrospectiva tomar en consideración las enseñanzas del Ejemplo 5 de D1 que revela el uso de almidón modificado y elegir un contenido de sal de 15% en peso o superior (con base en el contenido de agua).

- En contra de las enseñanzas de D1, elegir que la textura de gel debe ser obtenida mediante almidón modificado.

A este respecto me permito señalar que si bien las revelaciones de D1 contienen almidón modificado este se encuentra en forma inactiva toda vez que en dicha referencia el almidón modificado se utiliza con un propósito diferente (tal como se expuso anteriormente) y no como un agente gelificante.

Sin embargo, para utilizar el almidón modificado como agente gelificante debería ignorarse la guía que ofrece D1 en cuanto a que la modificación de la textura se realiza por medio del "agente espesante" (que es goma xanthan).

Más aún, tal como se ha expuesto anteriormente, el uso de almidón **modificado** no ha sido sugerido de ninguna manera por alguno de los documentos D2 o D3.

- Ajustar la cantidad de almidón modificado a través de ensayo y error toda vez que no se tiene alguna enseñanza a este respecto dentro de los documentos del estado del arte citado.
- Modificar la tecnología de producción revelada en D1 para lograr la producción de un producto en donde el almidón modificado es el responsable de la textura de gel, en vez el producto de D1 en donde el almidón modificado debe estar en forma inactiva pues se utiliza para un propósito diferente.

II. CONCLUSIONES

En conclusión me permito señalar a ese Despacho que en virtud de las modificaciones ahora realizadas al capítulo reivindicatorio de la presente solicitud y a la luz de los argumentos técnico anteriormente expuestos, el capítulo reivindicatorio ahora modificado de la presente solicitud goza de altura inventiva frente a las enseñanzas de los documentos D1, D2 y D3 y sus posibles combinaciones, toda vez que, en primer lugar, el Examinador técnico ha basado su argumentación en suposiciones con relación a las revelaciones de dichos documentos del estado del arte, suposiciones que, tal como se demostró de manera incontrovertible en el presente escrito, no son ciertas o no se encuentran sustentadas por algún documento del estado de la técnica.

Además, el Examinador técnico sugirió pasos que la persona versada en la materia debería realizar a fin de alcanzar la materia objeto de la presente solicitud, sin embargo los argumentos discutidos en el presente escrito han establecido de forma irrefutable que no existe ninguna motivación en el estado del arte citado por esa Oficina para realizar dichos pasos.

En este sentido, se estableció que el documento D1 es el único documento citado que revela el uso de almidón modificado pero las enseñanzas del mismo no conducirían de manera obvia a la persona medianamente versada en la materia al concentrado objeto de la presente solicitud toda vez que en D1 no se revela ningún gel ni se enseña que el almidón modificado sea utilizado como agente gelificante, y contrario a esto D1 guía a dicha persona a usar un agente texturizante.

Sumado a lo anterior, quedó claramente establecido que no existe ninguna enseñanza en D1 (o en D2 o en D3) que sugiera almidón modificado como agente gelificante y mucho menos que el almidón modificado sea utilizado como agente gelificante para proporcionar un gel en concentraciones altas de sal de entre 15 a 40% en peso, particularmente con una sinéresis reducida.

Por lo tanto, es a todas luces evidente que la persona versada en la materia no encontraría ninguna motivación a partir del estado del arte citado por esa Oficina para modificar las enseñanzas del documento D1, ni existe una sugerencia o motivación en dicho estado del arte de cómo modificar las enseñanzas de D1 para resolver el problema técnico objetivo de la presente solicitud y llegar así de forma obvia o evidente a la solución proporcionada por la solicitud denegada.

Consecuentemente, el concentrado reclamado por el capítulo reivindicatorio modificado de la presente solicitud, y por consiguiente también su proceso de obtención, no es obvio ni evidente a partir de las revelaciones del estado del arte más cercano citado por esa Oficina y por lo tanto es irrefutable que la presente solicitud sí goza del requisito de Nivel Inventivo frente al estado del arte más próximo citado en la Resolución Número **55960** ahora impugnada.

III. PETICIÓN

En vista de todo lo anterior, ruego a usted proceder a estudiar nuevamente la solicitud a la luz de las modificaciones y argumentaciones presentadas y proceder a revocar la Resolución Número **55960**, con el fin de que se conceda el privilegio de patente a la presente invención.

IV. PODER

Finalmente me permito recordarle a este Despacho que el documento que acredita mi calidad de representante legal en Bogotá para asuntos relativos a la Propiedad Industrial de la sociedad peticionaria, fue presentado ante dicha entidad junto con mi solicitud de fecha 25 de Febrero de 2008.

V. ANEXOS

Anexo al presente escrito me permito presentar:

- (i) Copia de las páginas 15 a 17 que corresponden al capítulo reivindicatorio modificado el cual consta de 15 reivindicaciones.
- (ii) Copia del documento *Resistant starch, a review of the physical properties and biological impact of RS3*; S. G. Haralampu; *Carbohydrate Polymers* 41 (2000) 285-292.
- (iii) Copia del documento *Specialty starches for snack foods*; M. G. Sajilata, R. S. Singhal; *Carbohydrate Polymers*, 59 (2005) 131-151.

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VI. DOMICILIO

Mi dirección es Calle 72 No. 5-83, Piso 6º, Bogotá D.C.

Del Señor Superintendente,



ALICIA LLORED A RICAURTE

T.P. 53.215

Dirección para Notificaciones: notificacionespatentes@lloredacamacho.com

REIVINDICACIONES

1. Concentrado empacado para preparar un caldo, consomé, sopa, salsa, jugo de carne o para uso como un condimento, dicho concentrado comprende:

- 20-80% de agua (% en peso con base en el concentrado total empacado),
- 10-30% (% en peso con base en el contenido de agua del concentrado) de un almidón modificado,
- 15-40% (% en peso con base en el contenido de agua del concentrado) de sal
- 0.5-60% (% en peso con base en el concentrado total empacado) de componentes que confieren sabor,

y en donde adicionalmente el concentrado está en forma de un gel.

2. Concentrado empacado de acuerdo con la reivindicación 1, en donde el concentrado comprende 15-30% (% en peso con base en el contenido de agua del concentrado) de sal.

3. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-2, en donde la cantidad de almidón modificado es 15-28% (% en peso con base en el contenido de agua del concentrado).

4. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-2, en donde la cantidad de almidón modificado es 20-26% (% en peso con base en el contenido de agua del concentrado).

5. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-4, en donde el almidón modificado es un almidón modificado químicamente, preferiblemente un almidón modificado con ácido.

6. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-4, en donde el almidón modificado es un almidón modificado con ácido.

7. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-6, en donde los componentes que confieren sabor comprenden uno o más de extractos líquidos o que se pueden disolver o concentrados de uno o más de carne, pescado, hierbas, fruta o vegetales, y/o sabores, y/o extracto de levadura, y/o proteína hidrolizada de origen vegetal, de soja, de pescado o de carne, y/o hierbas, vegetales, frutas, carne, pescado, crustáceos o particulados de los mismos.

8. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-7, en donde el contenido de agua total del concentrado es 40-60% en peso (con base en el concentrado total empacado).

9. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-8, en donde el concentrado tiene una actividad en agua a_w de 0.5 a 0.87.

10. Concentrado empacado de acuerdo con cualquiera de las reivindicaciones 1-8, en donde el concentrado tiene una actividad en agua a_w de 0.7-0.78.

11. Proceso para preparar un concentrado empacado para preparar un caldo, consomé, sopa, salsa, jugo de carne o para uso como un condimento, dicho concentrado comprende:

- 20-80% de agua (% en peso con base en el concentrado total empacado),
- 10-30% (% en peso con base en el contenido de agua del concentrado) de un almidón modificado,
- 3-40% (% en peso con base en el contenido de agua del concentrado), más preferiblemente 15-30%, lo más preferido 15-26% de sal
- 0.5-60% (% en peso con base en el concentrado total empacado) de componentes que confieren sabor,

y en donde adicionalmente el concentrado está en forma de un gel,

el proceso comprende los pasos de:

- a. mezclar todos los ingredientes, comprendiendo la mezcla:

- 20-80% de agua (% en peso con base en el concentrado total empacado),
 - 10-30% (% en peso con base en el contenido de agua del concentrado) de un almidón modificado,
 - 15-40% (% en peso con base en el contenido de agua del concentrado) de sal
 - 0.5-60% (% en peso con base en el concentrado total empacado) de componentes que confieren sabor,
- b. llenar la mezcla en un empaque,
 - c. cerrar el empaque,

en donde se aplica un paso de calentamiento d) antes de, y/o durante y/o después del llenado en el empaque.

12. Proceso de acuerdo con la reivindicación 11, en donde la mezcla comprende 15%-30% (% en peso con base en el contenido de agua del concentrado) de sal.

13. Proceso de acuerdo con la reivindicación 11 o 12, en donde el concentrado tiene la reología de un gel.

14. Proceso de acuerdo con cualquiera de las reivindicaciones 11 a 13, en donde al menos parte de la etapa de calentamiento es hasta una temperatura de al menos 60 °C.

15. Proceso de acuerdo con cualquiera de las reivindicaciones 11 a 13, en donde al menos parte de la etapa de calentamiento es hasta una temperatura de al menos 70 °C.

Resistant starch—a review of the physical properties and biological impact of RS₃

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Abstract

Resistant starch (RS) encompasses forms of starch, which are not accessible to digestive enzymes. By far, retrograded starch, and particularly retrograded amylose, are the most thermally stable forms. Retrograded amylose is especially useful as a source of thermally stable RS₃ for commercial food applications, since it survives most food processes.

Retrograded starch has been studied extensively for understanding the behavior of gels and certain staling processes in foods. Characterization of retrograded starch has been done as it interferes with the total dietary fiber (TDF) assay, with an emphasis on the negative impact of retrogradation. Until recently, little is known on the nutritional and commercial value for retrograded starch as an RS₃ product.

Early studies into the digestibility implied that retrograded amylose was non-nutritive, but more recent studies show that amylases, in fact, slowly attack the structure. Consequently, glucose and other oligosaccharides are released from retrograded starch over a sustained period through the normal digestive process. Modulation of glucose release and uptake in humans can be an important consideration in the use of resistant starch in food products for certain target groups, such as diabetics and athletes.

Sources of resistant starch are reviewed, with a focus on the principles behind the production of a food ingredient highly concentrated in retrograded amylose. Applications include a product for modulating the glucose response of diabetics, and effects on an extruded cereal product. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Total dietary fiber; Resistant starch; Glucose

1. Introduction

Resistant starch (RS) was first recognized as a complicating factor in the determination of total dietary fiber (TDF) levels by the Prosky Method (Englyst, Trowell, Southgate & Cummings, 1987). Since the definition of dietary fiber specifies “non-starch polysaccharides” (Asp, Furdá, Schweizer & Prosky, 1988), it is clear that any form of starch, which interferes with the assay, is not a traditional fiber. Subsequent research has shown that RS is not rapidly digested like ordinary starch, and that this feature imparts biological benefits. Some of the benefits are like traditional fiber, and others are unique to resistant starch. This article reviews the physical nature of resistant starch, its occurrence in food, its physiological benefits and potential use.

RS has been defined as the fraction of starch, which escapes digestion in the small intestine, and may be digested in the large intestine (Englyst, Kingman & Cummings, 1992). This is similar to the traditional definition, except

for the qualification that fiber is non-starch in origin. A number of factors contribute to starch’s resistance to digestion, which have led to four categories, each with similar resistance properties. They are as follows.

- RS₁: physically inaccessible to digestion by entrapment in a non-digestible matrix;
- RS₂: ungelatinized starch;
- RS₃: retrograded starch;
- RS₄: chemically modified starch.

RS₃ is of particular interest, because of its thermal stability. This allows it to be stable in most normal cooking operations, and enables its use as an ingredient in a wide variety of conventional foods.

2. Formation of resistant starch

Starch occurs in many plant tissues as a granule. Granules are usually between 1 and 100 µm in diameter, depending upon the plant source. Starch is comprised of two molecular types: amylose, the straight chain polyglucan comprised of

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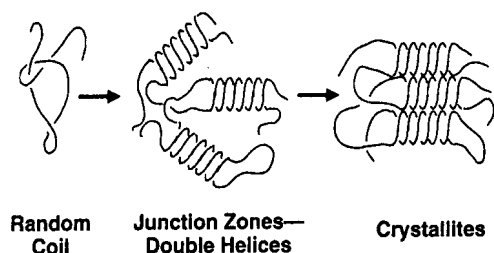


Fig. 1. Schematic of amylose retrogradation.

approximately 1000, α -D-(1 $\rightarrow$ 4) linked glucoses; and amylopectin, the branched glucan, comprised of approximately 4000 glucose units with branches occurring as α -D-(1 $\rightarrow$ 6) linkages (Zobel, 1988). Within the granule, starch is tightly packed in a radial pattern, and is relatively dehydrated. This compact molecular structure limits the accessibility of digestive enzymes, various amylases, and accounts for the resistant nature of raw starch granules, RS₂. In the diet, raw starch is consumed in foods like banana.

Starch granules are disrupted by heating in an excess of water in a process commonly known as *gelatinization*, which renders the molecules fully accessible to digestive enzymes. Some sort of hydrated cooking operation is typical in the preparation of starchy foods for consumption, rendering it rapidly digestible. Typically, starch hydrates at temperatures ranging from 40 to 120°C, depending on the source of the starch and its amylose content. Upon cooling, starch undergoes a relatively slow re-association process commonly termed *retrogradation*. During retrogradation (Colonna, Leloup & Buléon, 1992; Morris, 1990), starch molecules re-associate, and can form tightly packed structures stabilized by hydrogen bonding. The association process can be driven further by dehydration. These structures are thermally very stable, and can only be rehydrated

at 80–150°C, depending upon the extent and nature of the retrogradation. Amylose forms a thermally stable RS₃ complex, resistant to amylases (Jane & Robyt, 1984). It is found in foods such as cereal products and stale breads, and can be manufactured as a food ingredient.

In the formation of RS₃, the starch granule is completely hydrated. Amylose is leached from the granules into solution as a random coil polymer. Upon cooling, the polymer chains begin to re-associate as double helices, stabilized by hydrogen bonds (Wu & Sarko, 1978). The individual strands in the helix contain six glucose units per turn in a 20.8 Å repeat. Upon further retrogradation the double helices pack in a hexagonal unit cell. Schematically, the process is shown in Fig. 1.

High yields of stable, retrograded amylose were obtained by Sievert and Pomeranz (1989) when high amylose corn starch (amylomaize VII or *ae*-VII hybrid) was thermally cycled between 134 and 4°C in an excess of water. Enzyme resistance correlated with the enthalpy of the retrograded starch peak measured by DSC. The peak ranges from 120–165°C, and is apparently associated with the melting of amylose double helices.

Isothermal formation of RS is favored at 100°C (Eerlingen, Crombez & Delcour, 1993a). Higher temperatures are optimal, but not accessible to 1 atm operations. The thermal cycling of Sievert and Pomeranz (1989) may not be necessary to the extreme low temperature of 4°C, but it seems that cycling to 134°C is advantageous for the formation of extremely stable RS.

Amylopectin interferes with amylose retrogradation (Berry, 1986). Retrograded amylose yield may be increased by the removal of amylopectin with a debranching enzyme, such as pullulanase (Berry, 1986).

The degree of polymerization (DP) of amylose also affects the yield of RS₃ which rises with DP up to 100 and remains level above that (Eerlingen, Deceuninck &

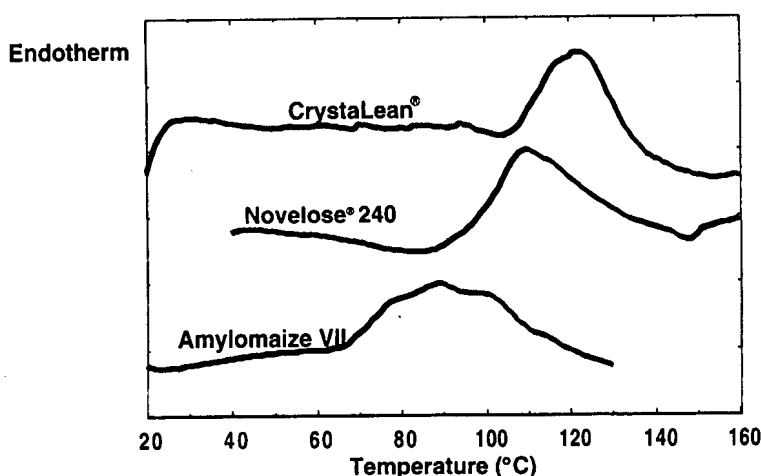


Fig. 2. DSC thermograms of commercial RS ingredients. Amylomaize VII is native granule of the *ae*-VII hybrid of corn and is a product of Cerestar, Inc. Hammond, IN. Novelose® 240 is a RS₂ product of National Starch and Chemical Company, Bridgewater, NJ. CrystaLean® is a RS₃ product of Opta Food Ingredients, Inc., Bedford, MA.

Table 1
Digestion of resistant starch and non-resistant starch with pancreatin

	Percent digested	
	2 h	24 h
Maltodextrin (5 DE)	95.9	99.1
CrystaLean®	39.6	53.8

Delcour, 1993b). This is supported by Gidley, Cooke, Darke, Hoffmann, Russell and Greenwell (1995) as minimum DP of 10 is necessary to form the double helix, and the maximum is about 100 glucose units. This indicates why amylopectin is so unfavorable to the formation of thermally stable resistant starch. Not only are the branches hindered in movement, but the typical lengths in them, 20–40 glucose

units, are far from the optimum of 100 (Eerlingen, Jacobs & Delcour, 1994).

In the commercial development of an RS product, it is advantageous to start with a native starch high in amylose. The naturally high level of amylose in the *ae*-VII hybrid of corn makes it particularly suitable. The thermal stabilities of various commercial products are compared by DSC in Fig. 2. When analyzed in a 3-times excess of water, the thermal transition can be related to the *melting* of the hydrogen bonded starch structures. In the amylo maize VII (*ae*-VII) hybrid of corn (Amylo maize VII, Cerestar, Inc., Hammond IN), containing approximately 70% amylose, the transition associated with gelatinization occurs between 65 and 120°C. This is the native RS₂, and thermally more stable than raw common corn starch.

The level of resistance in an RS₂ product can be increased by using hybrids, which have amylose levels higher than 70%. Also, starch granules may be fractionated by size to obtain higher amylose levels and higher levels of RS₂ resistance (McNaught, Maloney, Brown & Knight, 1994). Novolose® 240 (National Starch and Chemical Company, Bridgewater, NJ) is a thermally modified RS₂ based on the same *ae*-VII hybrid of corn (Shi & Trzasko, 1997). The modification renders the native granule more stable by holding the starch at elevated temperature (60–160°C) in the presence of limited water (10–80%).

RS₃ products have been proposed based on the *ae*-VII hybrid (Chiu, Henley & Altieri, 1994; Iyengar, Zaks & Gross, 1991). CrystaLean® (Opta Food Ingredients, Inc., Bedford, MA) is a commercial, highly retrograded RS₃ based on the *ae*-VII hybrid. It is produced by first fully hydrating and disrupting the starch granules, followed by an enzymatic debranching of the amylopectin to yield a low DE maltodextrin mixture, which is almost entirely a straight chain. Then, the mixture is treated through thermal cycles to achieve a high level of retrogradation prior to drying. DSC analysis shows that the endothermic peak is shifted significantly higher than either of the RS₂ counterparts to 105–145°C, which enables it to withstand most normal cooking operations.

Slow glucose release from retrograded amylose has been demonstrated *in vitro* by digestion with pancreatin at 37°C, to simulate the processes in the small intestine. Table 1 compares the rate of digestion of CrystaLean® with that of maltodextrin, an easily digested, starch hydrolysate, and shows that RS₃ is digested slowly, at approximately half the rate of maltodextrin.

3. Analysis

The concept of resistant starch is clear to most as the fraction of starch not readily digestible as *normal* starch. Quantification can be mired in definitions and analytical methods, however. Results from various analytical methods help to understand some of the physical characteristics.

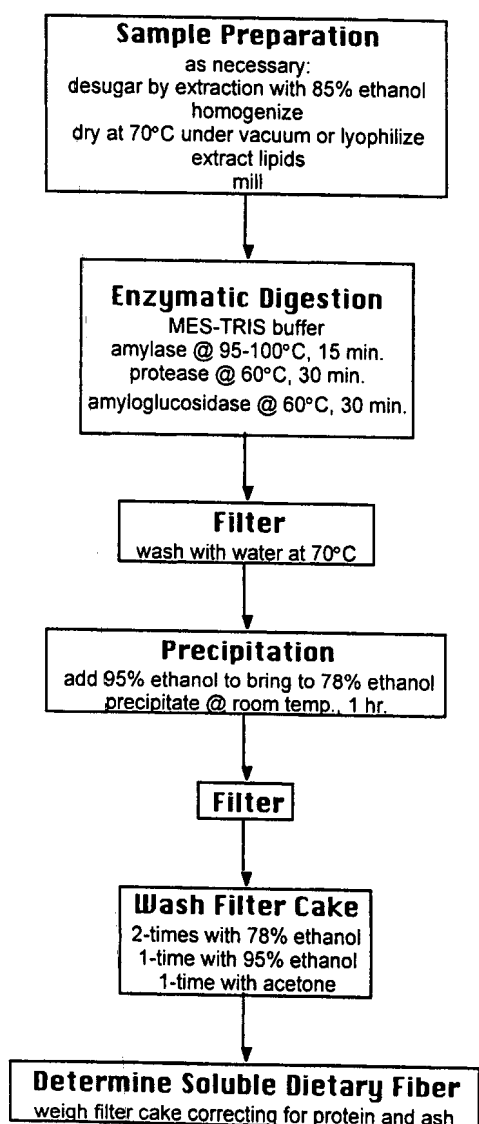


Fig. 3. AOAC/AACC method for total dietary fiber (TDF). AOAC method 991.43 and AACC method 32-07.

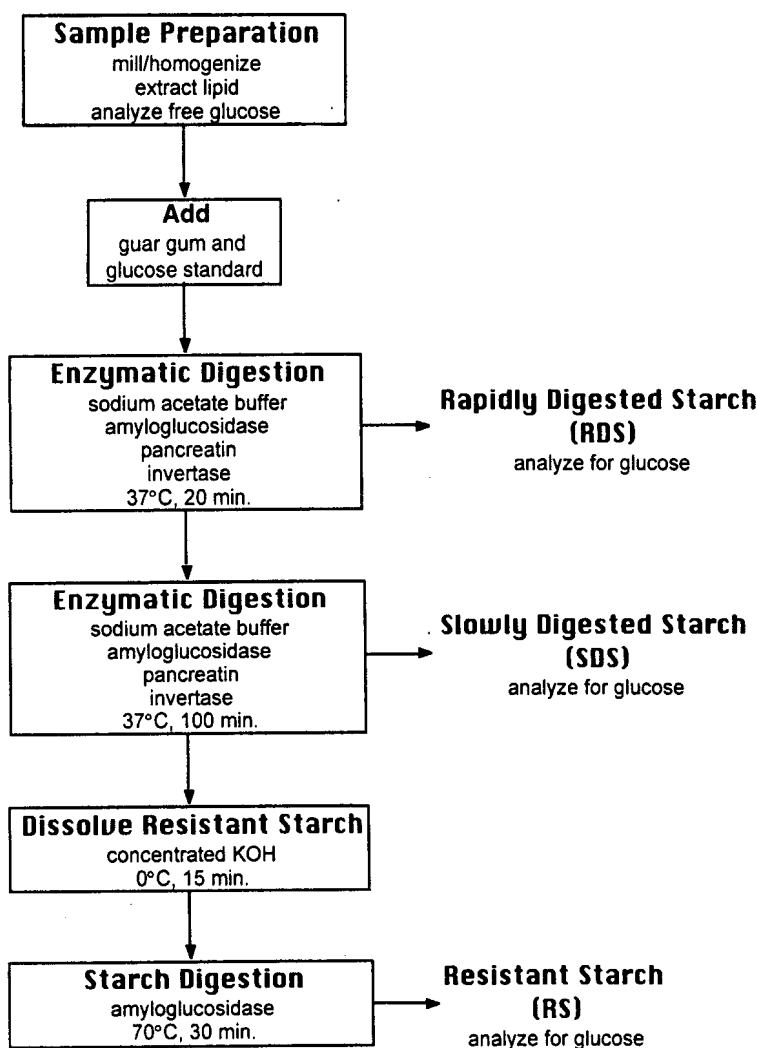


Fig. 4. Englyst method for resistant starch.

Since there is no regulatory definition of RS in the US, it is typically quantified as part of the TDF by the Prosky Method (Englyst et al., 1987). The fate of RS in an assay must be considered in the meaningful quantification of non-digestible and slowly digestible polysaccharides. One must be aware whether the intent of the assay is to provide a legal (regulatory) quantification of fiber, to provide a quantification of non-starch polysaccharides, or to truly reflect the in vivo resistant starch. The thermal responses of the three samples shown in Fig. 2 mirror the RS measurements by various methods. In general, the portion of crystalline structure melted in the assay is available to digestive enzymes, and measured as non-resistant starch.

The predominant assays for the regulatory determination of TDF are the AOAC and AACC methods. They are identical. Both old (AOAC 985.29 and AACC 32-05) and new (AOAC 991.43 and AACC 32-07) methods, the latter referred to as the Prosky Method, extract lipid, digest carbohydrate and protein enzymatically, and arrive at the remaining non-digestible fiber content gravimetrically. The

difference between the old and new methods is in the buffer system and washing solutions. The subtle change from a phosphate (old) to a MES-TRIS buffer, and changes in pH for the enzymatic digestions affect the TDF results with respect to RS. Shifting the washing to a more aqueous medium effectively removes oligosaccharides from the filter cake prior to the gravimetric determination of TDF. The new method (Fig. 3) provides lower estimates of TDF than the old method. Refinements have been proposed (Lee, Vincent, Prosky & Sullivan, 1996) to the basic scheme. Instead of determining the undigested carbohydrate gravimetrically, the digested carbohydrate is measured as glucose by a method like HPLC, and fiber is determined by difference.

Adhering to the formal definition of dietary fiber as non-starch polysaccharides requires several refinements to the AOAC/AACC methods. They are intended to fully digest the starch by rigorously solubilizing it in concentrated KOH or DMSO (Englyst, Wiggins & Cummings, 1982; Faisant, Planchot, Kozlowski, Pacouret, Colonna & Champ, 1995).

Since the amylase digestion in the AOAC/AACC methods is conducted at 95–100°C, as shown in Fig. 2, the high temperature melts some of the RS (either RS₂ or RS₃), leading to an underestimate of the RS available *in vivo*. Since RS has physiological benefits, improvements to get correct estimates include the use of porcine pancreatin at 37°C instead of fungal α -amylase at 95–100°C (Berry, 1986; Eerlingen & Delcour, 1995). This gives increased estimates of non-digestible carbohydrate, and accounts for the total polysaccharides passing the small intestine.

Englyst et al. (1992) have proposed an analytical method for rapidly digestible starch (RDS), slowly digestible starch (SDS) and resistant starch, with further fractionation into RS₁, RS₂ and RS₃. The sample is prepared at 100°C, which can disrupt the RS content or promote RS₃ formation. Next, the enzymatic digestions with protease, amylase and glucoamylase are accomplished at 40°C, which is close to that in the *in vivo* process. This method correlates to findings in healthy human ileostomates (Englyst, Kingman, Hudson & Cummings, 1996), and is truly indicative of physiologically important RS. A schematic of the method is given in Fig. 4.

Appropriate assay procedures are necessary when determining TDF when significant amounts of RS are present. The elevated temperature (95–100°C) used in the Prosky Method for regulatory purposes, is not favorable for RS determination, unless thermally stable RS, preferably RS₃, could be detected. Even small adjustments in the enzyme digestion conditions between the old and new AOAC/AACC methods affect the TDF determination. Ideally, resistant starch measurements should be done at physiological temperatures, but these methods are not currently accepted for regulatory declaration of fiber content. For research purposes, methods, which mimic *in vivo* conditions, need to be used.

4. Physiological effects

There is ample justification through nutritional studies that RS behaves physiologically like fiber, and should be retained in the TDF assay. RS assays as insoluble fiber, but has the physiological benefits of soluble fiber. Additionally, RS exhibits a level of slow digestibility, and can be used as a vehicle for the slow release of glucose.

Observations in animal systems are consistent between research groups, but the magnitudes of some findings differ. This is due to the lack of specificity in the definition of RS. Many times the apparent RS level in diets is confounded by the analytical method used for quantification, and it is sometimes unclear whether researchers use RS₂ or RS₃ in their studies.

Numerous studies in rats (de Deckere, Kloots & van Amelsvoort, 1995; Gee, Faulks & Johnson, 1991; Gordon, Topp, Shi, Zallie & Jeffcoat, 1997; McIntyre, Albert, Folino, Muir, Gibson & Young, 1994; Ranhotra, Gelroth,

Astroth & Eisenbraun, 1991; Rickard, Folino, McIntyre, Albert, Muir & Young, 1994; Younes, Levrat, Demigné & Rémésy, 1995) have shown that RS escapes digestion in the small intestine, and is slowly fermented in the large intestine. The general behavior of RS physiologically is similar to soluble, fermentable fiber, like guar. The most common conclusions include increased fecal bulk and lower colonic pH. Additional observations suggest that resistant starch, like soluble fiber, has a positive impact on colonic health by increasing the crypt cell production rate, or decreasing the colonic epithelial atrophy in comparison with no fiber diets. There is indication that resistant starch, like guar, a soluble fiber, influences tumorigenesis, and that serum cholesterol and triglycerides are reduced. Overall, since resistant starch behaves physiologically as a fiber, it should be retained in the TDF assay.

Further studies in humans support the findings of the rat model system (see Muir, Young & O'Dea, 1994). In the small intestine, RS may be slowly absorbed, but, more importantly, is associated with an increased malabsorption of starch. This results in decreased postprandial glucose and insulin responses. This effect, to be discussed later, has significant implications for the use of RS in food formulations for people with certain forms of diabetes. The interference with starch absorption also implies long-term benefits in controlling hyperlipidaemia. In the colon, RS increases fecal bulk, lowers colonic pH and the portion fermented by the intestinal microflora produces a wide range of short-chain fatty acids (SCFA), primarily acetate, propionate and butyrate (Kritchevsky, 1995; Muir et al., 1994; Phillips, Muir, Birkett, Lu, Jones & Young, 1995; Silvester, Englyst & Cummings, 1995). SCFA production has a positive impact on bowel health, including increased absorption of magnesium and calcium, epithelial proliferation, balance of bacterial species, and bacterial metabolism of bile salts. Whether through the action on bile salts or through dilution effects, RS is thought to provide a degree of protection against bowel cancer.

The findings in human subjects liken the physiological effects of RS to some fermentable dietary fibers (Kritchevsky, 1995; Muir et al., 1994; Phillips et al., 1995; Silvester et al., 1995). Since RS remains mostly undigested until it is partially fermented in the colon, the metabolism of RS occurs 5–7 h after consumption (Muir, Lu, Young, Cameron-Smith, Collier & O'Dea, 1995), in contrast to normally cooked starch which is digested almost immediately. A decrease in colonic and serum ammonia levels is also supported in humans (Silvester et al., 1995).

The work on resistant starch in humans is in its early stages, and some of the literature findings for rats are not yet supported. For example, the cholesterol lowering effect in rats is not found in human studies with normolipidemic subjects (Heijnen, van Amelsvoort, Deurenberg & Beynen, 1996).

The energy contribution of resistant starch is reported to range almost the entire gamut from 0 to 100% digestible.

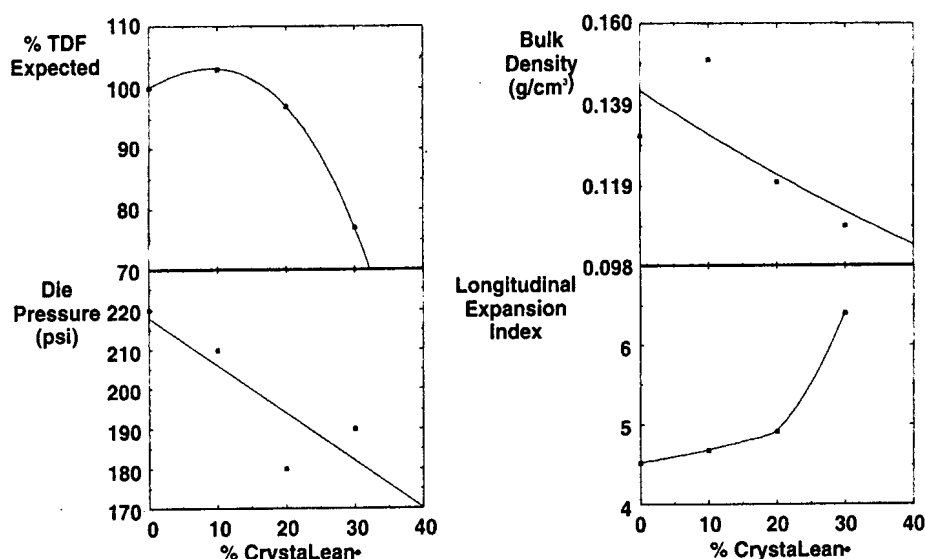


Fig. 5. Extrusion parameters of an expanded, corn-based breakfast cereal. The graph in the upper left shows the percent of RS surviving the extrusion process. The graph in the lower left shows the effect of RS on die pressure, which relates to a decrease in the specific mechanical energy with increasing RS. The two graphs on the right represent the physical nature of the extruded product, showing that overall bulk density increases with RS level, and that most of this is realized in the longitudinal expansion of the product.

Most of the studies indicate that 30–70% of RS is metabolized (Behall & Howe, 1995; Behall & Howe, 1996; Cummings, Beatty, Kingman, Bingham & Englyst, 1996; Ranhotra et al., 1991; Ranhotra, Gelroth & Glaser, 1996), while the balance is excreted in the feces. The variability is largely due to inconsistent definitions and assay procedures, and to effects caused by the malabsorption of other ingested starch.

The slow digestion of RS has implications for its use in controlled glucose release applications, particularly for diabetics. Digestion over a 5–7 h period reduces postprandial glycemia and insulinemia, and has the potential for increasing the period of satiety (Raben, Tagliabue, Christensen, Madsen, Holst & Astrup, 1994; Reader, Johnson, Hollander & Franz, 1997). In a human study (Reader et al., 1997) using a commercial RS₃ ingredient (CrystaLean®), the maximum blood glucose level and the area under the curve responses for serum glucose and insulin were significantly lower after consuming RS₃ than after other carbohydrates (simple sugars, oligosaccharides, and common starch). The RS₃ was incorporated into a bar type product. The glycemic response of subjects with type II diabetes mellitus was compared to the responses in subjects fed a common candy bar or a nutrition bar. All three bars had similar macronutrient contents. The study showed that the RS₃-containing bar decreased postprandial blood glucose, and may play a role in providing improved metabolic control in type II diabetes (non-insulin dependent). There may also be a benefit for diabetics by lowering lipid levels and prolonging satiety. Another study with CrystaLean® in dogs (Murray et al., 1998) supported the result that the postprandial area under the curve for glucose and insulin was reduced, and that RS in enteral formulas may improve

gastrointestinal tract health status due to fecal bulking, potential dilution of toxins and greater production of short-chain fatty acids.

RS has also been suggested for use in probiotic compositions to promote the growth of such beneficial microorganisms as *Bifidobacterium* (Brown et al., 1996). Since RS almost entirely passes the small intestine, it can behave as a substrate for growth of the probiotic microorganisms.

5. RS₃ in an extruded cereal

Traditional food fibers have a detrimental effect on the texture of many items, such as baked goods and extruded products. Fibers tend to strengthen the physical structure of a food and limit its ability to expand. Expansion of air cells is an important property in the development of texture during baking and extrusion.

RS₃ allows for the addition of high levels of material which assays as TDF, but does not interfere with structure, especially for extruded products (Zallie, Altieri, Chiu & Henley, 1996). When tested in an expanded, corn-based breakfast cereal formula, RS₃ was shown to have no detrimental effect on the structure. Fig. 5 shows the results of these extruder trials using the RS₃ product, CrystaLean®. The die temperature in these trials was 160°C, sufficient to *melt* the double helical structures in an excess of water (see Fig. 2). The RS₃ is relatively stable, however, because the process is run under a limited water condition of 16%. The upper left graph of Fig. 5 shows the percentage of RS surviving the process. Up to a 20% use level, essentially 100% of the RS survives and at a 30% use level approximately

22% of the RS is lost, presumably due to high shear damage in the extruder.

More importantly, the addition of TDF through an RS ingredient does not have a detrimental effect on structure, as can be seen in the bulk density of the product. If RS interfered with cell expansion in the extruder, a net increase in bulk density would be observed, and, in fact, the opposite is observed. Most of the decrease in bulk density is attributed to the increased longitudinal expansion of the product. It was also observed that the die pressure decreases with increasing level of RS₃. Hence, the addition of RS₃ to a conventional puffed corn breakfast cereal retains the textural properties of the product while increasing the TDF level, and decreasing the energy consumption of the process.

6. Summary

RS offers an exciting new potential as a food ingredient. It has been shown to possess physiological benefits similar to soluble fibers, and, in addition, to be used as a mechanism for sustained glucose release. Quantification of RS is problematic, since it is not a distinct chemical entity, but rather a set of physical states, which alter the rate of digestion of conventional starch. The most important aspect of an analytical procedure in the quantification of RS is the assay temperature. The traditional Prosky Method for quantifying TDF is conservative in assaying RS. With this quantification, physiological studies suggest that RS provides sufficient benefit to remain as part of the TDF assay. As definitions of RS become refined, the understanding and use of RS should increase.

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Specialty starches for snack foods

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Abstract

Specialty starches in snack foods serve as functional ingredients, contributing to desirable attributes such as increased expansion, improved crispness, reduced oil pick up and better overall eating quality. Starch-based coatings and adhesives can replace fat or oil in low-fat baked snacks. Dry hot melt starch-based adhesives are cost-effective tacking agents, while resistant starch provides high fiber nutritional claims for snack foods. The type of starches chosen will depend on their cost, availability, functionality and the quantity used. The present review highlights the functionality of specialty starches in a variety of snack foods. Types of specialty starches, their biochemical aspects, legal aspects and commercial availability are also discussed.

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Keywords: Specialty starches; Snack foods; Cross-linked starch; Dextrins; Pregels; Starch hydrolysis products; Starch esters; Starch ethers; Resistant starch

1. Introduction

Snack, defined as a light meal eaten between regular meals include a broad range of products that can take many forms. Definitions of snacks are being modified to include sandwiches, yogurt and even ice creams. Native starches are frequently limited in their food applications, due to cohesive texture, heat and shear sensitivity, lack of clarity, opacity and low viscosity. Retrogradation or precipitation can result on storage, posing additional problems. This has led to the production of specialty starches, which can provide consistent results specific to the needs of the products. Specialty starches continue to outpace unmodified starches in the processed food industry because of their ruggedness and ability to withstand severe process conditions. In selecting a specialty starch for a particular application,

both marketing and production requirements have to be considered. The market-related properties are product properties such as the structure (e.g. gelled), aesthetics (e.g. clarity, smooth or pulpy or grainy), organoleptic considerations (e.g. mouth feel, taste) and shelf stability (Dias, Tekchandani, & Mehta, 1997). The production-related requirements are properties like viscosity, resistance to shear, low pH, high temperature etc. Table 1 lists some of the specialty starches that can be prepared from various starch types and that also meet the formulation requirements.

Besides their textural and viscosity benefits, specialty food starches often reduce costs of established food products. More expensive ingredients such as tomato solids, fruit solids or cocoa powder can be extended with combinations of such starches, flavors and other inexpensive food substances. Considering the high degree of functional contribution, and the low rate of usage the cost allocation of specialty starch to finished product remains low (Langan, 1987).

2. Legality

Modified food starch is a food additive and limits of its modification, use and labeling are clearly defined in the US Code of Federal Regulations (21 CFR 172.892) (Moore, Tuschhoff, Hastings, & Schanefelt, 1984).

Abbreviations: SHP, starch hydrolysis products; DE, dextrose equivalent; MCC, microcrystalline cellulose; CMS, carboxymethyl starch; DS, degree of substitution; WAI, water absorption index; UHT, ultra high treatment; HP, hydroxypropylated; FDA, food and drug administration; DP, degree of polymerization; DF, dietary fiber; RS, resistant starch; WHC, water holding capacity; TDF, total dietary fiber; WPI, Whey protein isolate.

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Table 1
Types of specialty starches meeting some formulation needs

Marketing requirements	Regular maize	Waxy maize	High-amylose maize	Tapioca	Potato
Gelled	Thin-boiling		Thin-boiling		
Flowable	Stabilized	Cross-linked		Cross-linked	Cross-linked
Expanded		Cross-linked		Cross-linked	Cross-linked
Rigid			Thin-boiling		
Rubbery			Thin-boiling		
Clarity		Cross-linked		Cross-linked	Cross-linked
Opacity	Cross-linked		Cross-linked, Thin-boiling	Thin-boiling	
Pulpiness	Pregelatinized and cross-linked			Pregelatinized and cross-linked	
Smoothness		Cross-linked		Cross-linked	Cross-linked
Graininess	Cross-linked			Cross-linked	
High temperature storage	Cross-linked	Cross-linked		Cross-linked	Cross-linked
Low -temperature storage		Stabilized, cross- linked and stabilized		Stabilized, cross- linked and stabilized	Stabilized, cross- linked and stabilized
Low pH storage	Cross-linked			Cross-linked	Cross-linked

The European Directive on food additives allows the following food starches in foods.

- E1400: Dextrin (roasted starch)
- E1401: Acid treated starch
- E1402: Alkaline modified starch
- E1403: Bleached starch
- E1404: Oxidized starch
- E1410: Monostarch phosphate
- E1412: Distarch phosphate
- E1413: Phosphated distarch phosphate
- E1414: Acetylated distarch phosphate
- E1420: Starch acetate
- E1422: Acetylated distarch adipate
- E1430: Distarch glycerine
- E1440: Hydroxypropyl starch
- E1441: Hydroxypropyl distarch glycerine
- E1442: Hydroxypropyl distarch phosphate
- E1450: Starch sodium octenyl succinate
- E1451: Acetylated oxidised starch

Modified starches consist essentially of starch with low to very low levels of substituent groups. Extensive safety studies reviewed by independent regulatory bodies provide adequate assurance of their safety (Wurzburg & Vogel, 1984). Table 2 shows the chemically modified starches allowed for use in foods by the Food Chemicals Codex.

3. Specialty starches as functional ingredients

3.1. As fat replacers

3.1.1. Maltodextrins and other starch hydrolysis products (SHP)

Among the carbohydrate-based fat replacers are α -amylase converted tapioca and potato starches and

maltodextrins, having a DE of about 5 or less (Lenchin, Trubiano, & Hoffman, 1985) at 25–35% solids. The starches so prepared form gels in water that have a neutral taste and a smooth creamy consistency. The replacement products are comparable to the controls at the correct replacement level. Low DE maltodextrins based on potato starch based are fat replacers in low fat dressings and spreads (Minoru, Naoko, Masami, Masaki, & Tsukasa, 1993), while that derived from waxy maize can be used to replace over 50% of bakery fats in a range of bakery products. Hydrolyzates prepared by acid roasting of a native tapioca/sweet potato starch, having an amylopectin/amylose ratio of 80–85: 15–20, are useful as partial substitutes for oils and fats in butter cream (Minoru et al.). Batz, Mueller, and Drummond (1994) prepared a high moisture (50%), low-fat cheese product by mixing skimmed milk curd, starch hydrolyzate, salt and an emulsifier. At levels of 1–5%, maltodextrin imparts a custard-like texture to yogurt.

Carbohydrates having an spheroidal shape and a particle-size distribution of about 0.1–2 microns are reported to have the organoleptic character of an oil-in water emulsion (Singer, Chang, Tang, & Dunn, 1990). A fat-like carbohydrate characterized by a high strength starch gel comprising 20–30% by weight short-chain amylose is used in foods as a replacement for up to 100% by weight of one or more fats contained in foods. It is prepared by the enzymic debranching of cornstarch with pullulanase, which specifically degrades the α -1,6-D-glucosidic linkages of the starch molecule. The short-chain amylose may be used in a refined form or as a mix, further comprising long chain amylose, amylopectin or combination thereof. It may be modified by derivatization, conversion or cross-linking before or after debranching the starch. Foods in which the short chain amylose can be used in place of fat, cream, oil, oil-in-water and water-in-oil emulsions are ice cream, spoonable and pourable salad dressings, margarine low-fat spreads, low-fat cheese, baked foods, breaded foods, sauces,

Table 2
Chemical modifications of starch permitted in foods (USA) (Food Chemicals Codex, 1996)

Specialty starch	Treatment to produce the starch; residuals limitation
Gelatinized starch	Sodium hydroxide, not to exceed 1%
Thin-boiling or acid-modified starch	Hydrochloric acid and/or sulphuric acid/ α -amylase enzyme (GRAS)
Starch ether-esters	Phosphorus oxychloride, not to exceed 0.1%, and propylene oxide, not to exceed 10%; not more than 3 mg/kg of residual propylene chlorohydrin
Oxidized starch ethers	Chlorine, as sodium hypochlorite, not to exceed 0.055 lb (25 g) of chlorine per lb (454 g) of dry starch; active oxygen obtained from hydrogen peroxide, not to exceed 0.45% and propylene oxide, not to exceed 25%; not more than 1 mg/kg of residual propylene chlorohydrin
Bleached starch	Active oxygen obtained from hydrogen peroxide, and/or peracetic acid, not to exceed 0.45% of active oxygen. Ammonium persulfate, not to exceed 0.075% and sulfurdioxide, not to exceed 0.05%. Chlorine, as sodium hypochlorite, not to exceed 0.0082-lb (3.72 g) of chlorine per lb (454 g) of dry starch. Potassium permanganate, not to exceed 0.2%; not more than 0.005% of residual manganese (as Mn). Sodium chloride, not to exceed 0.5%.
Oxidised starch	Chlorine, as sodium hypochlorite, not to exceed 0.055lb(25 g) of chlorine per lb (454 g) of dry starch.
Starch acetate	Acetic anhydride or vinyl acetate; not more than 2.5% of acetyl groups introduced into finished product
Acetylated distarch adipate	Adipic anhydride not to exceed 0.12% and acetic anhydride; not more than 2.5% of acetyl groups introduced into finished product
Starch phosphate	Monosodium orthophosphate; not more than 0.4% of residual phosphate (calculated as P).
Starch octenyl succinate	Octenyl succinic anhydride, not to exceed 3%, followed by treatment with α -amylase
Starch sodium octenyl succinate	Octenyl succinic anhydride, not to exceed 3%.
Starch aluminium octenyl succinate	Octenyl succinic anhydride, not to exceed 2%, and aluminium sulfate, not to exceed 2%
Distarch phosphate	Phosphorous oxychloride, not to exceed 0.1%; sodium trimetaphosphate, not more than 0.04% of residual phosphate
Phosphated distarch phosphate	Sodium tripolyphosphate and sodium trimetaphosphate; not more than 0.4% of residual phosphate (calculated as P).
Acetylated distarch phosphate	Phosphorous oxychloride, not to exceed 0.1%, followed by either acetic anhydride, not to exceed 8%, or vinyl acetate, not to exceed 7.5%; not more than 2.5% of acetyl groups introduced into finished product.
Starch sodium succinate	Succinic anhydride, not to exceed 4%.
Hydroxypropyl starch	Propylene oxide, not to exceed 25%; not more than 1 mg/kg of residual propylene chlorohydrin.

whipped toppings, icings, pudding, custards, mayonnaise and coffee whiteners (Chiu & Mason, 1992).

3.1.1.1. Low-fat butter spreads/margarine. Low DE starch hydrolyzates having good water binding properties can function more effectively as fat replacers in comparison to high DE starch hydrolysis products (SHP). Potato starch hydrolyzate of DE 2–5 at 3–5% is suitable as fat substitute without any impairment in taste (Mishra & Rai, 2002). The capacity of these gels to compensate textural and physical properties of milk fat may be attributed to two mechanisms i.e. impact on mouth feel and colloidal properties of these hydrolyzates. In one study, a blend of hydrogenated fat and liquid oil was used for the preparation of low fat butter spreads. When the fat content of the spread was reduced to 57% by incorporating starch hydrolyzate along with hardened oil, the spread showed better spreadability at refrigeration temperature and better stand up properties at high storage temperature as that of commercial butter (Reddy, Nalinnakshi, & Chetana, 1999). The maltodextrin, termed SHP, is produced by α -amylase action on starch granules before and during gelatinization, rather than afterwards as in the case for conventional maltodextrins (Bulpin, Cutler, & Dea, 1984). Maltodextrins at 1–5% maintain body in sour cream.

A non-fat edible plastic dispersion which has rheological properties similar to solid margarine includes fat mimetic

selected from the group consisting of gelling type maltodextrin, starch modified by acid hydrolysis to remove amorphous regions, branched chain amylopectin starch, and inulin as a texturizing agent (Buliga et al., 1996).

3.1.1.2. Low-fat mayonnaise, salad dressings, sauces. The formulation of a low-fat mayonnaise consists of typically 60–78% water, 1–12% egg white (or other protein), 0.25–5.00% MCC and 1–15% polydextrose. Polydextrose may be replaced by maltodextrin with a DE of about 10 at 3–8% (Meiners, Merolla, Smagula, Bernardini, & Harkabus, 1992). A granular cold-swelling starch, at 3–7% of total product weight is a fat substitute in foods such as mayonnaise, salad dressings, sauces and dips (Melwitz, Spitzfaden, Seewi, & Stute, 1992). High-acid liquid systems such as pourable salad dressings are often thickened with modified and pregelatinized waxy starches. Low to moderate cross-linking is sufficient for the cling to salad contents (Langan, 1987).

A method of preparing the peanut spread comprises a premix of the granular starch hydrolyzate and water, fragmenting the granular starch hydrolyzate and then blending the resulting particle gel with a peanut component to produce a macroscopically homogeneous blend (Prosser, 1995). The fragmented granular starch hydrolyzate is capable of forming an aqueous dispersion at 20% solids.

3.1.1.3. Low fat milk type product (Wheelock, 1994). A new milk type product 'Halo' was developed by Northern Dairies, UK in response to consumer demand for low fat milk type product, using a fat replacer based on starch hydrolyzate with a more acceptable flavor and texture than semi-skim milk.

3.1.1.4. No-fat/low-fat ice cream (Gross & Haralampu, 1999). A formulation of skim milk 23.24 kg, non-fat dry milk 2.04 kg, sugar 3.86 kg, maltodextrin (5 DE) 1.45 kg, corn syrup solids (36 DE) 0.83 kg, stabilizer 0.08 kg, mono and diglycerides 0.06 kg and microcrystalline starch-based product 0.26 kg are dispersed in the liquid using an overhead stirrer for 5 min. The mixture is then pasteurized in a regenerating PHE in which the premix is heated to 71 °C in the regeneration portion of the heat exchanger and homogenized through a two-stage homogenizer (2000/500 psi) followed by pasteurization at 85 °C, for 25 s before being cooled to 4 °C. The premixes are aged overnight at 4 °C and frozen at −7 °C, packed in 946 ml containers and hardened overnight at −40 °C. The ice-cream formulation is organoleptically similar to normal ice creams. Potato starch hydrolyzate of DE 2–5 functions as a body and viscosity enhancing agent and fat substitute at 3.5% level in ice cream without impairment in taste of the product (Dorp, 1996b).

3.1.1.5. Baked low-fat snacks. Pregelatinized waxy cornstarches are used to produce low-fat snacks that are made by baking or by indirect expansion process (low-shear extrusion followed by microwave baking or frying). Pregelatinized waxy cornstarch is necessary because the temperature rises slowly in the dough and the raw starch does not have sufficient time to gelatinize (Huang & Rooney, 2001). In cakes, total replacement of fats with amylopectins and octenyl succinylated amylopectin results in higher firmness than control (Young, Won, Lim, & Lin, 2001). N-Lite B, of National Starch, a waxy maize starch-based maltodextrin, can be used to replace over 50% of bakery fats in a range of bakery products (Anon, 1993).

3.1.2. As clathrate inclusion complexes

The formation of clathrate inclusion complex is yet another form which can be used as a fat replacer. It can be prepared by suspending acetylated starch in water, heating the resultant suspension past the gelation point of the starting material, cooling the resulting hydrogel while adding a lipid such as a triglyceride and homogenizing the resulting product at a temperature below the melting point of the lipid in the case of fats and 45° (in the case of oils). The clathrates are stable and resistant to retrogradation, can be dispersed into a variety of foods, and also reduce fat in ice creams and tortillas (Nickel & Berger, 1996). Starch–lipid composites can be used as a fat replacer in low-fat beef patties (Warner, Eskins, Fanta, Nelsen, & Rocke 2001).

3.1.3. Modified starches and other miscellaneous forms

A microcrystalline starch-based product comprising resistant microcrystalline starch, glucose and short chain glucooligosaccharides can be used as a fat extender in low-fat or fat-free food formulations (Gross & Haralampu, 1999). A propoxylated starch-cross-linked acetylated starch mix that has been previously heated to 180 °C and cooled is reported to be useful in low-fat formulations of salad dressings, margarines and ice creams (Rispoli, Sabhlok, Ho, Scherer, & Giuliano, 1981).

A new fat-replacement technology, based on high-pressure steam cooking of starch and soybean oil, was developed at the USDA labs in Peoria, IL. It was found that after cooking starch and oil together, they obtained a gel that could be easily dried and ground into a powder. The oil did not separate out on further heating or freezing. It was reported that by using as little as 2% of this ingredient, called 'Fantesk' in a frozen dairy product, a 0.3%-fat ice milk had the same taste and texture as an 8-to-10%-fat ice-cream. Bedford, MA-based Opta Food Ingredients has obtained an exclusive license on Fantesk.

Hydroxypropyl starches may be used in conjunction with other thickeners for e.g. with carrageenan in milk systems to be retorted and with xanthan gum in salad dressings (Rutenberg & Solarek, 1984).

3.2. To reduce oil uptake

High amylose starches and tapioca dextrins form oil-insoluble films, which hinder oil pickup in fryers and oil migration into or out of the product (Huang & Rooney, 2001). Dough formed from vital gluten, gelatinized amylopectin from maize and a stabilizer or thickener produces a chip that possesses an excellent bite, and has a considerably reduced fat content in the finished product.

Esterified propoxylated starch has been used to prepare reduced-calorie French fries (Cooper, 1993). Carboxymethyl corn starch (CMS) at 0.5–3.0% has been shown to reduce fat content in the Indian deep fat fried snack 'sev', based on Bengal gram flour (Bhattacharyya, Chhaya, Singhal, & Kulkarni, 1995).

In case of cake donuts, partial replacement of the traditional wheat flour with rice ingredients, or using modified flour or starch (gelatinized long grain rice flour or precooked acetylated and cross-linked rice starch) as additives reduce the oil content. These additives have superior water-holding capacity and require extra water to maintain proper dough consistency and firmness of the doughnuts. The extra water added normally correlated to higher moisture content and lower oil uptake (Shih, Daigle, & Clawson, 2001). Doughnuts showing reduced oil absorption during frying can also reportedly be manufactured by using baking powder comprising NaHCO₃, rapid-acting acidic agents, slow-acting acidic agents and α -starch (Hisato, Hideyo, & Nobuyoshi, 2001).

3.3. To improve the handling properties of the dough/use of dough improvers, artificial flours

Pregelatinized starches that maintain their granular shape improve the handling and forming properties of the dough used to make expanded products (Huang & Rooney, 2001). 2–14% of high amylose starches (over 50%) improves the dough for leavened pastries with reduced thickness and proofing time, and gives tender stable crust of more uniform thickness and fewer tendencies to shrink (Radley, 1976). High amylose starch strengthens extruded pasta, inhibiting disintegration when retorted in the presence of sauce and adds crispness to extruded half-products which are later expanded in hot oil.

Starch phosphate in combination with amino acids (e.g. glycine) and anionic or non-anionic edible surfactants are useful as macaroni dough structure improver, which increases efficiency, reduces cracking during drying, and improves cooking properties (Schneider, Kalinina, & Ivanova, 2000).

A ready-to-bake, frozen bread dough using 1–20% artificial flour has been reported. The artificial flour consists of 30–70% protein and 70–30% modified starch. The modified starch may be cross-linked waxy maize starch, while the protein component may consist of gelatin and non-gelling gelatin, hydrolyzed gelatin and collagen (Ortiz & Sanders, 1996).

3.4. For instant puddings, dry mixes and instant gravies

Instant puddings are expected to have very smooth textures and heavy-bodied consistency. Since these mixes are high in sugar and other dry ingredients to aid dispersion, fine grind potato (owing to their blandness) pregels are recommended (Dias, Tekchandani, & Mehta, 1997). Lightly cross-linked tapioca with good refrigerator stability is preferred. Cross-linking is needed to avoid complete disruption during drum drying, which would result in an unacceptable slimy and cohesive texture in the pudding.

Acetylated starches are pregelatinized for use in dry mixes and instant gravies and pie fillings. The dry formulation consists principally of soluble starch, sugar flavoring together with salts, which produce enough viscosity in milk to keep the starch suspended until it hydrates. Upon addition of cold milk, the starch quickly dissolves and sets to a gel (Mitch, 1984). Cold water swelling starch phosphate with 3–4% bound phosphorus can be prepared by heat-reacting starch with a 1:2 mixture of NaH_2PO_4 at 150–165 °C, for 4–6 h. The starch is washed with alcohol and dry-mixed with sugar and flavoring and added to cold milk to form puddings, which set rapidly to have a smooth texture and good eating quality. Cold water swelling starch can comprise of a blend of at least 2 starch components, an amylose free starch and a starch containing at least 20% amylose which is used as a thickening agent in both cooked and instant food formulations e.g. gravies,

soups, sauces, dressings, hot beverage mixes and puddings (Eastman, 1987).

A pregelatinized starch phosphate of DS 0.7 gelatinizes at ambient temperatures, and is used in instant pie fillings, dessert powders and icings (Hoseney, 1994a; Othmer, 1995). Maltodextrins are sprayed on instant tea and coffee, instant soup mixes to keep the granules free flowing.

3.5. As thickening agents/replacers for pectin, vegetable solids

Cross-linked stabilized starches such as acetate, phosphates and hydroxypropyl ether starches derived from tapioca, potato and waxy maize either in granular form or after pregelatinization are used as thickeners in baked, frozen, canned and dry foods. They are used in fruit pie fillings, tarts and gravies (Dias, Tekchandani, & Mehta, 1997). Succinate derivatives of starch have been recommended as binders and thickening agents in soups, snack, canned and refrigerated products.

A new specialty starch product, amylopectin potato starch, developed with the aid of modern biotechnology, containing only amylopectin can be used as a thickener/stabilizer in a wide range of sectors of the food industry (Vries, 1995). A dual esterified starch with low gelatinization point and a high peak viscosity in noodles improves their consistency and mouth feel. The starch will gelatinize and absorb water before the wheat flour takes over and dominates the viscosity profile. Pregelatinized starch is used as a bodying agent for caramels and marshmallows.

A no sugar or reduced sugar beverage or beverage concentrate with an intense sweetener usually contains a gelatinized starch; it compensates for the lack of body, texture and viscosity that is traditionally provided by added sugar (Mills & Gristwood, 1999).

3.5.1. Sauce, ketchup, jams, jellies

A thermally inhibited, subsequently hydrolyzed by glucoamylase to split α -D-glucosidic linkages in ungelatinized granular starch has been shown to be a useful food ingredient, particularly fruit or vegetable-based products. The resultant starch of DE 20–30 reduces the amount of tomato solids in tomato-based products such as ketchup, barbecue sauce, tomato sauce and salsa without loss of viscosity or texture (Senkeleski, Zallie, & Hendrikx, 1999). The starch is useful in fruit-based food products, particularly when a starch is desired which is relatively easy to cook out at high solids, provides a short texture, controls moisture migration, has a clean flavor and/or provides a relatively low hot viscosity during processing e.g. in fruit preparations, jams, jellies and fruit fillings to reduce the amount of pectin or even replace it in total without a loss in viscosity (Xu, Senkelski, Zallie, & Hendrikx, 1999). Pulpy texture can be introduced to sauces with the aid of highly cross-linked and specially processed corn or tapioca pregels (Langan, 1987).

A pizza sauce with improved eye appeal and mouth feel can be obtained from cold water swelling, cross-linked instant starch. Such starch is easy to disperse in cold mixtures or oil and adds a pulpy richer look to fruit based sauces. Cross-linking imparts the starch with resistance in acid foods, and even allows retorting. Maltodextrins add body to canned sauces. The use of a 10 DE starch hydrolyzate in a frozen pizza sauce results in more sheen, a brighter red color and a more desirable body and texture, compared to a control sauce (Murray & Luft, 1973).

3.5.2. Pie fillings, toppings

Starch obtained from plants with a triple recessive genotype with 2 dosages of waxy and one dosage of amylose extender (wxwxae) produces a strong resilient gel, which clears from the mouth uniquely fast. The unique and distinctive texture makes the starch suitable as a replacement for conventional gelling gums such as natural gums and gelatin in whole, or in part in bakery application e.g. cream or fruit fillings for pies such as lemon, banana cream and in low or reduced fat high solids fruit centers for cookie such as fig bars (Hauber, Friedman, & Katz, 1996). Pregelatinized starch is used as a thickening agent for pie fillings.

Cross-linked starch is used to produce viscous systems in acidic media such as in cherry pie filling. The acidity from the cherries speeds the hydrolysis of the α -1,4 glucosidic bonds in the starch during baking, and thus produces a thin pie filling. Cross-linking does not stabilize the bonds to the acid; however, with sufficient cross-linking, the starch swelling is greatly restricted and as the acid hydrolyses the bonds, viscosity increases instead of decreasing. Therefore, with the right degree of cross-linking, one can end up with a thick pie filling (Hoseney, 1994a). Pregelatinized starch from a cross-bonded waxy cereal starch if used, the filling is subjected to only the heating it receives during baking and even this can be eliminated if desired. The juice thickened without heating keeps the fruits suspended, and avoids the loss of the fresh flavor of the fruits (Osman, 1984). Hydroxypropyl distarch phosphate and/or starch acetate is used as thickening agents for paste-like foods such as toppings, fillings, fruit preserves (Hasegawa, 1984).

3.5.3. Soups

Corn potage soups with good viscosity have been obtained with starch phosphate (Nireki, Hayasaka, Kawamoto, & Yoshida, 1989), and also with highly cross-linked or substituted waxy maize or dent corn.

3.6. As substitutes for gum arabic (as tackifiers/edible films)

Roasted dextrin, oxidized starches, gelatinized starches, and cross-linked starch derivatives can be used as substitutes for natural gums especially gum arabic in food processing (Hanmo, 1986). Acid-thinned hydroxypropylated tapioca starch as a gum arabic replacement, lowers

coating time, since the viscosity of the starch is low even at 50% vs. a maximum 40% for gum arabic. Lipophilic starches can successfully replace a large portion of gum Arabic offering advantages of excellent emulsion stability and finished beverage quality (Light, 1990).

3.6.1. As edible films/protective coatings/glaze

Edible high-amylose corn starch films are permeable to air, oxygen and nitrogen, and have been proposed for packaging. They require plasticization to prevent brittleness and approach the strength of cellophane. Starch derivatives are also used as protective coatings on candies, nuts and chocolate candies.

Clear films obtained by dehydration of tapioca dextrin solutions are often used as protective coatings (as a replacement for gum arabic) such as in pan coating of confections (Langan, 1987) as a non-tacky glaze for cakes, donuts, fruit, nuts and candies. Tapioca specialty dextrins replace from 20 to 40% of gum arabic in some hard gum candies. Coating the hot surface of a freshly baked item with a high concentration of tapioca dextrin forms a film that retards moisture migration. A sealant for baked goods for reducing the moisture migration into and out of the baked good comprises sucrose 40–72%, starch hydrolyzate of DE < 38, 8–30 and water 20–30 weight % (Huang, Timm-Brock, Sward, Abrams, & Gaertner, 1993).

Almonds may be coated with a 50% solution of a 10 DE-hydrolyzate. The solution is heated to 160 °F and sprayed onto nutmeats in a revolving pan coater. The nutmeats are then dried in an oven at 120 °F. The coated almonds are found to be crisper after 3 weeks of storage. It is well known that a continuous starch film is about 98% effective in barring the transfer of O₂ and these low DE hydrolyzates may have some of these barrier properties. Hydroxypropylated starches are used as edible films.

3.6.2. As tackifiers

The new starch-based hot-melt system is a water-free free flowing oil preblended dry powder, which melts in < 30 s when applied to the hot snack (121–150 °C). The seasonings adhere to the products. The powder is very stable at temperatures below 93 °C. The starch-based hot-melt system provides greater tackiness than canola and other vegetable oils. It outperforms oil alone as an adhesive for seasonings. It also allows friendly labeling as corn syrup solids.

A dextrin coating at 30% solution in water or glycerine can be sprayed onto snacks to adhere seasonings. The solution is easy to spray at a high solids concentration (30–40%) due to its low viscosity characteristics (Huang, 1995; Huang & Rooney, 2001). Dextrins are used to tack water-soluble flavors to low-fat baked snacks. They are made by pyroconversion-controlled heating of dry acidified starch in a reactor with good agitation. The products have high water solubility, low viscosity and good film-forming ability (Huang & Rooney). As adhesives, they are used in

pan coating to prevent separation of the sugar shell from the base center material (Moore et al., 1984).

3.7. As dusting agent

Pregelatinized starch is used as a dusting agent perhaps mixed with powdered sugar for candy gums (Mitch, 1984). Cornstarch can be modified to make it completely unwettable. This water-resistant starch is put to use in dusting applications (Langan, 1987). The more powder-like consistency of oxidized starches makes them ideal for dusting foods such as marshmallows and chewing gums (Brown, 2000).

3.8. For puffed/expanded products

Pregel starches contribute to the puffing properties of baked snack (Moore et al., 1984). Waxy starches usually produce the greatest expansion, but tend to give a tacky mouth feel. Cross-linking reduces the tackiness, but also tends to decrease expansion (Langan, 1987). Excessive cross-linking lowers the swelling capacity of the starch, resulting in a snack that has reduced expansion with non-uniform poor texture. Proper cross-linked waxy cornstarch controls the expansion of snacks (Huang & Rooney, 2001). A cross-linked waxy starch can be combined with a cross-linked non-waxy starch to make a puffed fat-fried snack. The mix with salt and flavoring is formed into dough and gelatinized, shaped and dehydrated to 10–14% moisture, deep-fried and puffed (Radley, 1976).

Foods that expand greatly upon microwave baking without surface breakage is obtained by coating the surface of the dough with α -amylase or acid-hydrolyzed starch prior to baking (Kanbara & Mori, 1989).

Expandable starch can be prepared by acidification of native cassava starch suspension with 0.08–2% of dry starch organic acids such as lactic acid, citric acid, acetic acid and tartaric acid, addition of iron ions and oxidation with 0.03–0.9% hydrogen peroxide at temperatures below gelation temperature (20–45 °C) for 1–48 h. The expandable starch thus obtained is suitable for preparation of breads; oven roasted or fried products having expanded surface and croquette texture (Oviedo & Manuel, 2001).

For hollow puffed foods, cream puff shells, snacks and fried foods, the dough contains 100 weight parts starch materials selected from starch (amylose content $\leq$ 25 weight %), cereal flours and their gelatinized, acetylated and etherified products and 10–150 weight parts milk products which are coagulated unripened and added to water 35–60 weight % (Nakano & Sato, 1998).

A baked, wheat-based, chip-like snack food with surface air bubbles is made from pregelatinized waxy cornstarch (approx. 3–20%, by weight), pregelatinized potato starch (approx. 1.5–20%, by weight) and, optionally, modified potato starch. The ratio of the amount of pregelatinized waxy starch to the total amount of potato starches may be

from 0.45–1.00:1.00. The pregelatinized waxy starch and potato starch are at least substantially hydrated prior to baking; this allows bubbles to be produced and retained, and controls the crisp, crunchy texture of the snack food (Carey, Moisey, Levine, & Slade, 1998).

A shelf-life snack food can be produced from fruit or vegetable juices or juice concentrates. Mixing of juice and/or its concentrate with a starch hydrolysis product and pregelatinized starch can form dough, which on heating expands due to evaporation of water and producing products with cracker or cookie-like appearance and texture (Gimmeler, Levine, Slade, Faridi, & Sauer, 1996). Kerapok or fish crackers made from slurry with water: tapioca starch ratio of 70: 30 pregelatinized at 133.5, 143.6 and 151.8 °C had linear expansion greater than the minimum acceptable value of 77% (Yu & Low, 1992).

3.9. Starches for free-flowing high-fat foods

High-fat or oily foods such as peanut butter or chocolate liquor can be made free-flowing for dry packaging by plating onto extremely low-density modified tapioca or waxy corn dextrins. The density is reduced through special techniques of gassing with ammonia or CO₂ and spray drying (Langan, 1987).

3.10. As drying aids

Low DE SHP s are well known drying aids through their elevating effect on sub-zero glass transition temperature and reducing the fraction of unfrozen water. The combination of low solubility and low hygroscopicity makes the low-DE carbohydrates especially useful as a carrier and drying aid for many dehydrated foods such as dry peanut butter, dried citrus powders, spray-dried oils, wine flavors, apple juice powder, vegetable powders and sweetening agents. Citrus purees can be successfully spray dried with 30–40% of a 10 DE hydrolyzate (Murray & Luft, 1973).

3.11. As extrusion aids

Carboxymethyl starch from waxy amaranth starch is shown to be useful as extrusion aids in ready-to-eat extruded snacks prepared from semolina (Bhattacharyya, Singhal, & Kulkarni, 1996). Pregel starches are used to control cold flow and slumping of extruded shapes (Moore et al., 1984).

3.12. As texture improvers

Texturizing agent in low-fat and fat-free foods such as mayonnaise, margarine, salad dressing, mousse, cottage cheese dressing, sour cream, ice cream, yogurt and cream cheese comprises an insoluble micro particle such as TiO₂, xanthan gum and pregelatinized starch in the form of

a complex in which the insoluble micro particle has been stabilized or entrapped. (Finocchiaro, 1995).

High amylose cornstarch is used in extruded and fried snack products to obtain crisp, evenly browned product. Crunchy or crispy mouth feel can be obtained with the use of high amylose starches or slightly degraded waxy pregels that expand to tender structures when heated and dried. Snacks have a high degree of mouth melt, less waxiness, improved texture and increased crispness by incorporating a modified starch and/or high amylopectin flour or starch into the dough composition and by controlling the water absorption index of the starch-based materials. 50–70% of the starch-based material must contain at least about 3.2% modified starch comprising at least about 3% hydrolyzed starches having a DE 5–30 and WAI 0.4–8 g per gram of modified starch (Villagran, Dolores, Villagran, Lanner, & Hsieh, 2002).

Cross-linked acetylated starches are used in canned, frozen, baked and dry foods; also in fruit and cream pie fillings in cans and jars to provide desired textural properties and viscosity breakdown resistance (Rutenberg and Solarek, 1984).

Food products such as baked goods (cone, cookie, wafer), use either a high-molecular weight starch hydrolyzate of DE 5–30 or a crystallite hydrate producing sugar such as raffinose or trehalose or combination thereof to increase the crispness of the product at higher moisture levels (Huang, Pnada, Rosenwald, & Chida, 2002).

Chewiness can be introduced with highly cross-linked waxy corn starch used at relatively high levels. Cornstarch tends to release with relative ease from the mouth as compared to waxy corn. Tapioca is often chosen over corn for release of flavor. Cross-linking helps mouth release because it shortens the consistency and lowers levels of usage (Wurzburg, 1987).

Adding modified waxy cornstarch to oat flour improves the quality of extruded snack foods (Karam, Grossmann, & Silva, 2001), and also for improving the texture and crispness of sheeted snack foods and crackers (Anon, 2001). Starch esters such as hydroxypropylated di-starch phosphates can impart stability and textural properties to dairy products (Dorp, 1996a)

3.12.1. Microwave cooking

One of the major problems associated with microwave cooking is the sogginess that occurs at the interface of wet and dry surfaces such as in pizza pies and breaded meat or fish. Predusting the surface with high amylose starches and flours with a slow hydrating pregel controls the moisture at the intersurface (Light, 1990).

3.12.2. Pasta cocktail snack foods (Cock, 1995)

Pasta cocktail snack foods, made from potato starch and granules, pregelatinized starch and salt, are produced by extrusion followed by drying, frying, flavoring and packaging. Effects of incorporation of 7% pregelatinized starches

and maltodextrins from different origins (corn, waxy corn and potato) on texture of pasta cocktail snack foods showed waxy cornstarch to give a harder, crisper and denser product, and incorporation of potato starch to give a softer and less dense texture. Using corn maltodextrins, the extrusion capacity, crispness, chewability and brittleness increase with an increased DE value of the maltodextrins. Cross-linked starch ether (cross-linking degree 0.01–1) to the dough markedly improves reconstitution and texture of dried pasta (Nippon, 1984).

3.12.3. Fruit preparations

Cross-linked highly stabilized waxy maize starches can result in high viscosity even at 60% sugar concentration (Anon, 1992b).

3.12.4. Cheese

Cheese is mixed with molten salt and $>$ or $=1$ compound selected from the group comprising oxidized starch, esterified starch and etherified starch, then melted with heating and emulsified to give a cheese resistant to freezing and resistant to crumbling in frying oil (Hisaku, 1994).

3.12.5. French fries

Potato products prior to deep fat frying may be coated with an aqueous dispersion of high amylose starch acetate (of DS 2.5) to give potato chips that are exceedingly crisp both when fresh as well as after prolonged storage. They are strong and rigid without being tough and have excellent flavor. A hydroxypropyl ether of amylose having a DS of 1.5 can also be used to get the same effects. Similarly, a thin boiling amylose product prepared by the treatment with sodium hypochlorite of cornstarch with a high amylose content of 65% by weight, the final product being converted to a degree known in the trade as 70 fluidity can also be used to coat the potato products (Gutcho, 1973a).

The physical properties and taste of cooked potato products may be markedly improved by contacting and reacting raw, peeled potatoes with an aqueous medium containing a suitable cross-linking agent to form cross-links between the labile hydrogen atoms on the alcohol moieties of the starch and sugar molecules on the surface of the raw potatoes. The potato products possess markedly superior and long lasting crispness and greatly improved color and flavor (Gutcho, 1973b).

3.12.6. Biscuits, cheese buns, cookies

Fermented tapioca starch termed 'sour starch' contributes unique flavor and texture in sour starch biscuits and cheese buns. A premixed unbaked dough preform containing a starch hydrolyzate of DE $<$ or $=42$ at $>$ or $=8\%$ of the total dough weight produces cookies that maintain their fresh texture for long (Evans, Dodson, & McConvis, 1967).

3.12.7. Milk-based products

Starch hydrolyzates increase the spreadability of milk solid-based spreads. It has also been used for micro-encapsulation of milk fat (Onwulata, Smith, Craige, & Holsinger, 1994). Frozen desserts made with a 10–15 DE hydrolyzate have a much slower meltdown and a better texture than desserts prepared with a 36 DE corn syrup. A marshmallow made with a 10 DE hydrolyzate for variegating ice cream retains a marshmallow consistency and texture after freezing and thawing because of its high molecular weight saccharide content (Murray & Luft, 1973).

3.12.8. Puddings, creamy desserts

Higher consistency and firmness of UHT puddings and higher creaminess of UHT creamy desserts is obtained with hydroxypropylated distarch phosphate derivative of a waxy maize starch (De Coninck, Vanhemeliujnck, & Peremans, 1995). For smooth pudding-like textures, tapiocas seem to do a slightly better job than waxy corn (Langan, 1987). Cross-linked waxy cornstarch significantly improves its appearance and texture in pie fillings (Brown, 2000).

3.12.9. Cakes

The cake mix industry has rapidly converted to the extra-moist cake formulas, where pregel starch softens the cake crumb and retains moisture in the baked product. Substitution for about 4% of the flour in cakes with pregelatinized starch has been reported to improve the eating quality (Osman, 1984).

Drum-dried cross-linked starches with low amylose content are claimed to improve cake volume, softness and keeping quality of cakes (Rutenberg & Solarek, 1984). Acid-modified starch has a greater tenderizing effect than an equal amount of unmodified wheat starch in angel cakes (Osman, 1984). Lightly inhibited and stabilized waxy corn and tapioca pregels are excellent for retaining moisture and softness in baked cakes and cookies (Langan, 1987). Sweet potato starch phosphate monoester improves cake quality markedly (Wu, Yang, & Tian, 1998).

3.12.10. Bread

Bread manufactured by partially substituting wheat flour with modified starch such as wheat starch acetate and activated gluten results in softer texture even after 3 days as compared to the control (Mizoguchi & Takayanagi, 1991). Breads manufactured by mixing 0.5–10 weight % α -cross-linked starch (swelling degree, 4–35) in grain powder containing wheat flour as a main raw material is improved in aging and gives soft feeling on eating (Mizoguchi, Yanetani, & Yamashita, 1992). Resistant starch (RS) can be used as a texture modifier, crisping agent in bread (Yue & Waring, 1998).

Breads manufactured using a composition containing wheat flour 62–92.5, hydroxypropyl starch and/or starch acetate 7–30, and α -starch 0.5–8 weight parts have glutinous

texture. The addition of 5–7% of starch phosphates improves the volume and freshness retention of the finished loaf (Radley, 1976). Dextrins act as antifirming agents in bread (Hoseney, 1994b).

3.12.11. Farinaceous snacks

Low-calorie farinaceous snacks containing high amylopectin flour or starch in the dough results in snacks with a high degree of mouth melt and increased crispness (Gutcho, 1973a; Martines, Villagran, Villagran, Lanner, & Yen-Ping, 2002).

3.13. For stability to high shear, acid and high temperature conditions

Hydroxypropyl starches are usually cross-linked to obtain desired texture and resistance to the high temperatures, low pH and shear degradation often encountered in food processing. They may be used in granular or as pregelatinized, cold-water-soluble product. Cross-linked starches are resistant to low pH and shear, but they lose their clarity and water-holding capacity on prolonged low-temperature ageing. By acetylating cross-linked starches to an acetyl content of 0.5–2.5% the resistance to shear is retained and the cold ageing stability is improved. For high shear processes, moderate to highly cross-linked starches are normally required. Hydroxypropyl distarch phosphate shows good stability in retort foods.

Functions of potato starch can be improved by conjugating starch and whey protein isolate with a covalent bond (Yang, Hattori, & Takahashi, 1995; Hattori, Yang, & Takashi, 1995).

3.13.1. High temperature gelling starches

They are useful to provide a gel texture at temperatures significantly above those of conventional gelling starches e.g. 70 °C (Trzasko, Tessler, & Dirscherl, 1986).

3.13.2. Vegetable-based foods

A thermally inhibited, subsequently enzymatically hydrolyzed (glucoamylase to split α -D-glucosidic linkages, 0.1–1% by weight of starch) ungelatinized granular starch has been shown to be a useful ingredient in fruit or vegetable-based products. The resultant starch (DE 20–30) is useful in vegetable-based food products, particularly when a starch with relatively high process tolerance against heat, acid and/or shear, high viscosity, and stability against gelling, a clear flavor, and/or prevention against serum separation is desired (Senkeleski et al., 1999).

3.13.3. Salad mayonnaise/dressings

Salad mayonnaise produced with stabilized starches cross-linked with adipate group displays improved storage stability to high levels of shear, enabling the most modern equipment to be used without sacrificing end product quality (Doreau, 1994). Hydroxypropylated distarch phosphate

derivative of waxy maize gives advantages of its use as a thickener in hot processed 30% oil dressings.

3.13.4. Fruit preparations

Modified waxy maize starches in fruit preparations such as acetylated starch adipate or hydropropoxylated starches show good acid and shear stability (Thys & Dorp, 1998).

3.13.5. Custard

An important component in bake-stable custards is the UHT-stable modified starch. Preferred starches are acetylated distarch adipate and hydroxypropyl distarch phosphate (Bilsen, Scholtes, Jacobus, & Van Zon, 1995).

3.13.6. Dairy desserts

Hydroxypropylated starches from tapioca and acetylated and hydroxypropylated starches from waxy corn show advantages in their use in UHT dairy desserts (Dorp, 1996c) or gelled desserts, distarch adipate or distarch phosphate or a native corn/waxy blend appears to be useful for the UHT process, but in order to obtain the desired texture, carrageenan must be added (Rapaille & Vanhemelrijck, 1984).

3.13.7. Xanthan gum-modified starches (Cheng & Wintersdorff, 1981)

Xanthan gum-modified starches are characterized by increased acid stability, by heat and shear stability, and by increased resistance to dissolution in aqueous media. The novel process by which this is made comprises: heating to gelatinize an aqueous starch-xanthan gum blend below 100 °C, continuing heating to reduce the moisture content to about between 5 and 10%, then further drying the mixture (typically to below 7% moisture) above 100 °C long enough to cause interaction between the starch and xanthan gum. Drum drying that combines the heating and drying steps is preferred heating method. Another embodiment is a process comprising drying (preferably on a drum dryer) an aqueous mixture of xanthan gum and gelatinized starch in 1:5–50 parts above 140 °C so as to cause a modification of the precursor starch by the xanthan gum. The decomposition temperature of the precursor starch limits the maximum drying temperature. Typically 204 °C is the maximum drying temperature. Gelatinizing and co-drum drying an aqueous xanthan gum, unmodified tapioca starch mixture in a 1:5 weight ratio milled to a desirable particle size above 200-mesh (e.g. through 14-mesh, on 20-mesh) results in a finished product that exhibits a rapid hydration rate in water to form pregelatinized, texturized, swollen particles having a firm and crispy texture. Although commercial pregelatinized, texturized starches are grainy and pulpy, they are not as firm and crispy in texture compared to the xanthan gum-modified tapioca starch product. These starches can be used in tomato sauce mix, apple-sauce mix, instant dry mix vanilla pudding, instant imitation jelly, lemon pie filling, French type dressing, improved textured vegetable proteins

or meat extenders. Other food uses include soups, spaghetti sauces, fruit drinks, meat sauces, gravies, and tapioca desserts, or instant foods. As such, they are used in the same manner as commercial pregelatinized modified starches.

3.14. For freeze-thaw stability/low temperature stability/prevention of syneresis

Waxy rice starch with 98% amylopectin is known for its creamy gel texture and natural heat and freeze-stability. Waxy rice starch is better than waxy maize or waxy sorghum starches in that the gels can withstand 6–7 number of freeze-thaw cycles without syneresis or irreversible setback compared to the gels of waxy corn or sorghum which are stable to only 3 cycles (Radley, 1976). In conjunction with waxy starches, high-amylose starches can produce gels of good strength and stability to syneresis. Tapioca, potato and waxy cornstarches, which have a relatively high degree of stability, require acetylation for low temperature stability (Rutenberg & Solarek, 1984). A non-gelling starch with good freeze-thaw stability and good mouthfeel is a waxy starch, which has greater than 30% by weight of short chains with a DP of 13 and converted to a water fluidity of 20–45. Particularly useful waxy starches are hybrid starches from a plant of wx su2 genotype and starches from waxy rice, barley and amaranth (Huang, Jeffcoat, & Mason, 1997).

3.14.1. Mayonnaise

Salad mayonnaise produced with acetylated distarch adipate or acetylated distarch phosphate displays improved storage stability to syneresis (Doreau, 1994; Rainer, 1984).

3.14.2. Pie fillings, gravies, puddings

To produce a stable sauce or pie filling, chemical modification of starch by adding blockers such as acetyl or hydroxypropyl groups separate amylose chains within the granule. This inhibits retrogradation, improves freeze-thaw stability and water holding capacity. Cross-linking tends to counter freeze-thaw stability so the best low-temperature storage stability is found in lightly cross-linked, highly stabilized waxy starches. Hydroxypropyl distarch phosphate shows good freeze-thaw stability (Jang, 1998).

The hydroxypropylated distarch phosphate derivative of a waxy maize starch shows perfect freeze-thaw stability even after 15 consecutive cycles and hence suitable in cooked pie fillings. Also, this starch specifically improves edibility, texture and taste of the cooked pie fillings (De Coninck et al., 1995).

Hydroxypropyl starches (of DS 0.05–0.10) are used as thickeners in gravies, sauces, fruit pie fillings and puddings where they must impart a smooth, thick, clear, non-granular texture that will hold up under various storage conditions including freezing and also impart no taste (Hjermstad, 1984). Starch monophosphates due to their superior freeze-thaw stability, are preferred to other starches

as thickeners in frozen gravy and frozen cream pie preparations (Othmer, 1995).

3.14.3. Sauces

Sauces made with waxy corn flour gives no appearance of separation after 12 months of frozen storage (Radley, 1976). Stability to freeze-thaw cycles can be greatly improved by the introduction of acetyl or propionyl groups in combination with cross-linking.

Resistance to freeze-thaw deterioration of cross-linked starch derivatives is obtained by treating them with α -amylase (Radley, 1976). A thermally inhibited, subsequently enzymatically hydrolyzed to give a starch of DE 20–30 is useful in reducing serum separation in barbecue and tomato sauce during storage (Senkeleski et al., 1999).

3.14.4. Rice-cake like foods

Rice cake-like foods are manufactured by mixing more than 10 weight % starch acetate, carbohydrate sweeteners and water, heating, forming into a shape and coating with corn starch mainly comprising of amylopectin. The foods are stable at less than 10 °C and maintain rice-cake firm textures after defrosting or heating (Hatsuta, Makisako, & Hiroya, 1991).

3.14.5. Fruit preparations

Hydroxypropylated (HP) starches can be used for syneresis reduction in fruit preparations (used for yogurts, dairy desserts etc.) (Watter, 1996). A thermally inhibited, subsequently enzymatically hydrolyzed ungelatinized granular starch, when used in fruit preparations for use in yogurts significantly reduces the interface that occurs between the fruit and the white mass, and also the color bleed from the fruit into the white mass (Senkeleski et al., 1999).

3.14.6. Non-freezing custard cream

A milk product, sugar and one or more modified starch (selected from the group comprising etherified starch, esterified starch and cross-linked starch) are mixed at a specific weight ratio, sterilized, combined with frozen, sugar-treated egg yolk to give custard cream not freezing in the refrigerator. The custard is preserved for a long time at low temperature (Nojiri, Nakai, Nakani, & Nakagome, 1994).

3.15. For encapsulation of flavor oils

Extrusion of hydroxypropyl distarch phosphate, acetylated distarch adipate or acetylated distarch phosphate (prepared from tapioca starch or corn amylopectin) along with an essential oil flavor (2–10% w/w) and emulsifier (4–20% w/w), mixed with a weighting agent and sweetener and/or acidulant (0.1–4.0% w/w) is reported prepared for use as a soft drink flavor component (Gonze, Van, Freddy, & Wastijn, 1990).

Sodium starch octenyl succinates are characterized by good filming properties and the ability to form very fine, stable emulsions, two key factors for very effective encapsulation of flavor oils by spray-drying (Trubiano, 1995a). They are superior in performance over other encapsulating agents or carriers, such as powdered gum arabic and maltodextrins. Dextrins can also replace gum arabic in the encapsulation of flavor, oils (Moore et al., 1984).

3.16. For clarity

Clarity is best obtained through the use of waxy starches. Cross-linked waxy cereal or root starches have proved excellent for use in fruit pie fillings in which clarity of the paste is a particular asset (Osman, 1984). In canned specialty products such as Chinese style foods, where clarity is exceptionally important to maintain the attractive appearance of vegetables, special cross-linked waxy maize starches perform satisfactorily (Glicksman, 1984).

Lightly derivatized starch acetates give clear gels of good stability, and are employed in frozen fruit pies and gravies, baked goods, instant puddings and pie fillings (Othmer, 1995).

3.17. As suspending agents

Cross-linked starches are superior to native starches in their ability to keep food particles in suspension after cooking (Othmer, 1995). To suspend particulate matter, moderate to lightly cross-linked waxes are recommended. These starches have high hot viscosities, which will hold the particulate in place until the paste has a chance to cool. Pregelatinized waxy or tapioca starches are sometimes used to suspend uncooked or partially cooked starch particles in cold aqueous systems so that the starch will not settle out during a cooking stage. This technique is used where agitation during cooking presents problems (Langan, 1987).

3.18. In coating batters for adhesion, crispness, low fat absorption

Oxidized starch is known to give better adhesion of the batter coating to the foodstuff (Lachmann, 1969a) such as fish and meat, and is widely used in breaded foods (Rutenberg & Solarek, 1984). The use of oxidized amylaceous materials provides a batter mix for breaded, deep fried foods which is vastly superior in all respects to batter mixes prepared from ordinary starches or flours. The batter mix components display a degree of adhesion to deep-fried foods, which is so tenacious as to actually render the breaded batter coating into an integral component of the foodstuff (Lachmann, 1969a). Use of oxidized starch batter mixes in the preparation of deep-fried scallops, which are suitable for immediate consumption, or subsequent freezing results in breaded coatings with a pleasant, firm texture,

golden brown color with no crumbing. Cross-linked waxy cereal or root starches can form the base of a batter mix for coating foods for deep fat frying (Osman, 1984).

Adhesion of breaded coatings for baked or fried meat or fish is greatly improved with the inclusion of lightly inhibited and bleached cornstarch in the batter (Langan, 1987). The batter mix consists of a mix of 210 parts of water and 90 parts of cornstarch, which had been treated for 30 min with 5% of chlorine, as, based on the weight of corn starch (Lachmann, 1969a). Coating crispness is further enhanced with the inclusion of modified high amylose starches. Modified high-amylose starch used in batters for breaded products form films when cooked retarding moisture movement. Rice flour based batter formulations with 15% oxidized cornstarch and MCC can be used as an alternative to traditional wheat flour-based batter for chicken drumstick coating. This results in a healthier product due to lower fat absorption (Mukjprasirt, Herald, Boyle and Boyle, 2001). French fries coated with batter containing 60–90% wheat flour and 10–30% high amylose starch imparts a very smooth appearance with firm crispness (Anon, 1994).

Deep-fried foods such as shrimps manufactured by covering with wheat flour batter containing starch phosphate (swelling ratio 53) (21% w/w), egg white powders (11% w/w) and calcium phosphate (3% w/w) show no deformation or taste deterioration when sealed in a retort pouch and heated at 121 °C for 30 min (Kawana, Yamana, Inaguma, & Ishiguro, 1992).

An esterified starch batter (at solids content content 40%) provides good adhesion and produces a crunchy and crispy breaded batter coating (Furcsik & DeBoer, 1992) for foodstuffs that are subjected to deep fat frying and then served immediately after frying; or foodstuffs that are prefried, frozen and then reheated after freezing.

3.19. For canned foods

A can-filling starch which has an initial high viscosity to facilitate uniform can filling, and exhibits viscosity breakdown on heating to increase heat penetration for sterilization, and a thin final viscosity is claimed for cross-linked acetylated tapioca, potato and waxy corn starches. FDA regulations permit up to 2.5% acetyl content in starches used in foods (Rutenberg & Solarek, 1984).

3.20. As binders/for WHC

Modified tapioca starches give higher viscosity than corn, waxy maize or wheat starches to bind a certain amount of water in meat giving a more succulent and juicy final product (Pszczola, 1999). Treatment of a suspension of 1:5 parts of starch: water at pH 9.4 with ultrasound for 35 min, followed by neutralization, washing and drying is reported to give storage-stable particles for sausage manufacture (Ajinomoto, 1983). Pregelatinized potato starch improves

water-binding capacity in paneer (Sethi, Thind, Padda, & Bakshi, 2003).

3.21. As emulsifiers/starches for eggless products

Enzymic degradation carried out before or after preparation of the starch derivative (containing a hydrophobic group) provides an emulsifier with improved shelf stability, and has applications as a replacement for gum arabic (Chiu, 1993; Trubiano, 1995b). Hydrolysis of the starches with glucoamylase after derivatization are useful as emulsifying and/or encapsulating agents, particularly in systems where high load and retention of the active ingredients, low surface oil exposure and good oxidation resistance is desired (Keller et al., 1999).

In low-viscosity pourable dressings or flavored beverages, the oil-in-water emulsions are best protected through the use of lipophilic substituted starches or dextrans.

3.21.1. Beverages

Lipophilic groups attached to dextrin or starch help stabilize emulsions (Langan, 1987). Sodium starch octenyl succinates are unique specialty food starches characterized by emulsion-stabilizing properties in soft drink beverages over spray-dried gum arabic in terms of lower use level. An emulsifying agent as a substitute of arabic gum consists of lecithin 3 parts and tetra glycerin pentaoleate 5 parts by weight added to 1000 parts of starch hydrolyzates to make an emulsion and then mixed with hydroxy propyl distarch phosphate 25 and xanthan gum 0.5 parts by weight (Hanno, Okuma, & Hoshii, 1988).

3.21.2. Mayonnaise and dressings

An eggless mayonnaise can be formulated using starch octenyl succinate or cornstarch phosphate (Dias, 1997). Octenyl succinate starches are used as salad dressing stabilizers. These are added in the processing or storage of fat- and oil-containing food products to improve the stability of fats and oils and the appearance, flavor and taste of the products (Hiroaki, Hozumi, & Kazuyuki, 1994).

A combination of starch phosphate, guar gum and propylene glycol (for control of thixotropic effects) can be used as an emulsion stabilizer for vinegar and vegetable oil in water.

3.22. As stabilizers

3.22.1. Ice cream

Carboxymethyl starch added to plain ice cream (0.3–0.5%) or fruit-berry ice cream (0.5–0.75%) results in superior taste, aroma, structure and consistency, color and appearance (Olenev, Zhizhin, Borisova, & Ustinova, 1984). Lower DE starch syrup contains more dextrans, which tie up more water in the mixture exerts a greater stabilizing effect against coarse texture in ice creams.

3.22.2. To prevent crystal formation in cheese

Hydroxypropyl distarch phosphate from waxy maize starch at 0.5–1% serves as a binding agent and also halves the added processing salts in comparison with known recipes of cheese, thereby preventing crystal formation efflorescence on the cheese surface (Merkenich, Maurer, Walter, Scheurer, & Klostermeyer, 1992; Merkenich, Maurer, Walter, Scheurer, & Klostermeyer, 1993).

3.22.3. As low-calorie sweeteners

Hydrolyzates of hydroxypropyl starches containing > 15 weight % of polymers of 2–6 DP, prepared enzymatically or by acid hydrolysis are suitable as low-calorie sweetener composition in bakery products (Quarles, 1992).

3.22.4. Starches as casein replacers/dairy-food substitutes

Modified starches and dextrins have been used successfully to replace caseinates in meat emulsions, coffee whiteners and imitation cheese (Yoder, Chang, Xu, & Domoras, 1996). Total or a partial caseinate replacement composition for imitation cheese can be made from a granular hydroxy propylated high amylose starch having a DS > 0.04, gelatin and a gum such as pectin and carrageenan. The gum is used to decrease the amount of gelatin necessary and to improve the texture of the overall cheese analog (Yoder et al., 1996). Pregelatinized modified high amylose (> 40%) starches, preferably converted and/or derivatized is another alternative for a similar purpose. Short chain amylose prepared by enzymatic debranching of starch is useful in imitation cheese as caseinate replacer (Zallie & Chiu, 1990).

Oxidized starches prepared by acid- or enzyme-conversion, oxidized starch prepared by treatment with less than 5% active chlorine and dextrins having fluidity of 50 are also suitable. Derivatives prepared by treatment with < 25% propylene oxide, 5% succinic anhydride and 10% octenyl succinic anhydride or with a sufficient amount of acetic anhydride or sodium or potassium *ortho*- or tripolyphosphate as well as unmodified high-amylose starches (up to 80%) are also useful (Zusiercan, Lacourse, & Lenchin, 1986).

A specialty starch produced from modified waxy maize has good gelling and water binding properties and a low gelation temperature. Its inclusion in meat products such as frankfurters and cooked chicken joints as a casein replacer results in low drip loss, firm texture and greater succulence (Anon, 1992a).

A dairy-food substitute composition comprising of 6–10 parts by weight of oil in a carbohydrate matrix, 4–8 parts of maltodextrin of DE 2–5, emulsifier and antioxidant with optional addition of vitamin and minerals, can be used to prepare an instant custard mix (Strong, 1989).

3.23. As clouding agents

Octenyl succinate starches can be used as clouding agents for direct use in soft drink beverages or spray-dried drink mixes (Wurzburg, 1987).

3.24. Starches for fish, meat pastes

Seafood pastes are manufactured by mixing paste materials (e.g. frozen ground meat or fish meat) with 0.5–12% modified starch and 0.001–0.2% cystine. The pastes have good mold-releasing properties, firm texture and high quality even after freezing. Frozen ground meat is kneaded with sodium chloride, 0.5% acetylated starch and 0.05% cystine, packed in cases and heated at 90 °C for 40 min in water to manufacture kamaboko (Myabe, Nakajima, & Kokai, 1989).

Addition of cross-linked hydroxypropyl starch and/or cross-linked starch acetic acid ester, cross-linked starch phosphoric acid ester, cross-linked starch octenyl succinic acid markedly increases elasticity and organoleptic test scores of kamaboko and other fish paste products (Ichiro, Naoyuki, Norishige, Yasuo, & Toru, 1987; Nippon, 1984).

3.25. Starches with low adhesion properties

Noodles manufactured with acetylated tapioca or potato starch showed excellent taste (Nakamura, 1996). Addition of starch acetyl ester to dough at 0.2–3.0% markedly increases the shelf life of cooked noodles (Shimadaya, 1984). The inner surface of cellulose sausage casings is coated with a mix of starch ether, a wax and optionally a silicone or plant oil prevents adhesion between the food and cellulose film/casing (Hammer, Winter, Kindl, & Luchterhand, 1984). Rice cooked with oxidized waxy cornstarch hydroxypropyl ether prevents sticking of cooked rice (Masuda, Sato, Kato, & Yamazaki, 2002).

3.26. Starches for use in plate heat exchangers

Cross-linked waxes produce higher viscosities than cross-linked corns, which is of particular importance when selecting a blend for processing in plate heat exchangers. High-viscosity pastes strain heat exchanger gaskets and lower product throughput. Lowering total starch concentration will lower gasket strain and increase throughput, but will produce a weak-bodied dressing. Lowering the waxy-to-corn ratio will relieve back pressure on the heat exchanger, but will also bring about changes in finished texture. As the corn portion is increased, the smooth salve-like texture is decreased. If the corn portion is allowed to get too high, there can also be problems with tailing at the filler causing stringing of the product to the outside of the containers. Obviously, the proper starch selection is a balance blend to produce a satisfactory consistency and texture (Langan, 1987).

3.27. Starches for high fiber nutritional claims

Resistant starch, billed as a functional fiber, is well suited for snack applications, since it allows high fiber nutritional claims. It also imparts excellent texture without

compromising quality. The RS crystallites are much smaller than those in traditional sources of fiber, and therefore do not adversely affect texture (Huang, 1995). Unlike traditional sources of dietary fiber, which hold significant moisture and impart a gritty mouth feel and characteristic fiber taste, RS has low water-holding capacity, small particle size and bland flavor. Commercial RS is a special high-amylose starch that has been modified by biochemical and/or physical processing to maximize its total dietary fiber content. RS provides snack processors the opportunity to produce high-quality fiber-fortified snacks for health conscious customers (Huang & Rooney, 2001).

A microcrystalline starch-based product comprising glucose and short chain glucooligosaccharides and having an average particle size of less than 10 μ can be used as a dietary fiber supplement (Gross & Haralampu, 1999). A high amylose starch with greater than 40% by weight amylose content and a water content of 10–80% by weight is heated to a temperature of about 60–160 °C to provide a granular starch which retains the granular structure and has a total DF content of greater than 12% (Yong & Trzasko, 1997). Any native or pregelatinized high amylose starches containing at least 30% amylose is hydrated to allow for sufficient molecular mobility for retrogradation to occur. Prior to or during retrogradation, the starch may be debranched by enzymes, to enhance retrogradation. The retrograded starch is further modified by hydrolysis of the amorphous non-crystalline regions with α -amylase or glucoamylase to produce glucose and short chain glucooligosaccharides while leaving the resistant microcrystalline regions intact. This may be dried to a powdered form. Gums, hydrocolloids may be added to change the rheology or increase the water-binding capacity of the product. This product can be

incorporated into food and beverage formulations in either the aqueous or dried form.

Indigestible dextrins rich in dietary fiber are obtained by roasting cornstarch in the presence of HCl, followed by hydrolyzing the roasted products with α -amylase and glucoamylase, then removing most of the glucose fractions (Matsutani, 1994).

Chemically modified starch, which is resistant to α -amylase and may serve as a low calorie additive to breads or crackers, so that it may act as a source of dietary fiber. The modified starch may be prepared from any type of food grade starch and preferably takes the form of a phosphorylated di-starch phospho-diester, with a mixture of sodium trimetaphosphate and sodium tripolyphosphate in the presence of a sodium salt acting as the phosphorylating agent (Seib & Kungsoo, 1999).

3.28. Starches for gum confections

A major requirement for use of starch in jelly gums is that it be thin-boiling. This is often achieved by acid conversion or oxidation. Thin-boiling starches can be successfully cooked in the presence of high concentrations of sugar to form strong gels (Evans & Wurzburg, 1967). In starch gum candy production, non-waxy cereal starches with acid modification are advantageous owing to their ability to produce highly concentrated fluid paste, which form gels upon cooling and ageing. Acid-hydrolyzed fluidity starches are used as gelling agents in the manufacture of gum jellies such as jellybeans, gummy bears and orange slices (Dias, Tekchandani, & Mehta, 1997). A typical composition of starch gum candy is 100 lb-granulated sugar, 150 lb of 63 DE corn syrup, and 40 lb of 70-fluidity acid-modified starch, 7 gal of water and

Table 3
Preparation of chip-like products

Ingredients	1	2	3	4	5	6
Waxy maize starch, inhibited and acetylated with 4.6% by weight of adipic–acetic mixed anhydride containing 1 part adipic acid and 50 parts acetic anhydride					260	440
Tapioca starch			400			
Waxy maize starch				400		
Bran-free enriched white wheat meal	3750					
Whole wheat, quick cooking brown wheat meal		500				
Acetate ester of a high amylose corn starch resulting from treatment of a high amylose cornstarch containing 55% by weight amylose with 5% by weight acetic anhydride	3750	500			260	60
High amylose corn starch containing 55% by weight amylose		600				
Acetate ester of high amylose corn starch resulting from treatment of high amylose corn starch containing 70% by weight amylose with 5% by weight acetic anhydride			600			
Dried cheese powder	100				51	105
Onion powder	10				8	5
Caraway seed	20					
Sal	30				22	22
Paprika					5	
Pizza flavor					2	
Monosodium glutamate						2
Water	7600	1000	1050	1000	392	366

Table 4
Commercial specialty starches

Trade name of the commercial specialty starch	Name of the company	Description and uses
Remygel 663-B-P	A and B Ingredients, USA	Precooked, acetylated and cross-linked rice starch that reduces oil uptake of wheat donuts at 25% wheat flour replacement; also increase firmness.
Remyflo R 500P		Gelatinized long grain rice flour that reduces oil uptake up to 64% at 50% replacement of wheat flour in wheat donuts.
HP starch C Cream 06718		Hydroxypropylated distarch derivative of waxy maize starch (DS-0.08) with well-defined advantages under severe processing conditions such as UHT, high shear, acid conditions; also has good freeze-thaw stability;
C*(AraTex 75701)		A gum arabic replacement in the sugar-free gum application. This acid thinned hydroxypropylated tapioca starch lowers coating time, since the viscosity of this starch is low even at 50% of the total amount vs. a maximum 40% concentration for gum arabic.
C*Pulp tex		Pregelatinized starch, which can replace expensive tomato- and potato-based ingredients.
C*Tex	Cerestar Euro Centre Food, Belgium	Waxy maize starch esters for stabilizing fruit preparations
C*Polar tex		Hydroxypropylated waxy maize starch ether to manufacture high quality chilled sauces without syneresis on storage.
C*Cream tex		Stabilized, high cross-linked, tapioca starch that has a short, creamy texture in finished products and a bland flavor; also has good heat and shear resistance, paste clarity and cold storage and freeze-thaw stability.
Staley mira-sperse 622		Agglomerated instant starch and maltodextrin for easy maximum dispersion. Even in cold water, it starts to disperse immediately.
Staley mira-sperse 626		Modified food starch—instant starch—for soups and dry mixes requiring starches that disperse readily in hot water. It is agglomerated for superior mixing and flow and for lump-free end-results in dry mixes.
Staley soft set	Tate and Lyle Food Ingredients, Decatur	Modified food starch, enables the no-cook preparation of spoonable, textured salad dressings. It sets to a soft gel without the need for heat or refrigeration.
Staley Lo temp- 452		Waxy modified starch makes cook-up quality possible in gravies and other products where high temperatures would harm the product formation.
Granular starch		Instantized without gelatinization by means of a novel manufacturing process to physically disrupt internal granular structure for gelling, thickening, easy-dispersing and low pasting temperature; used for dry mixes, gravies and sauces.
Staley's instant stellar		Modified corn starch that has been acid hydrolyzed to produce a loose association of crystallites; xanthan gum is added to aid dispersion and hydration of these crystallites.
Novation 9330, 9360		Used as a fat replacement system for baked goods, frostings and fillings, dairy products, salad dressings, cheese products, table spreads, meat products, confections and frozen dairy desserts. Can endure moderate heat processing with not much loss of quality.
Novation 8600	National Starch and Chemical Company, Bridgewater, NJ	Functional native tapioca starch for improving texture and mouthfeel of soy yogurt. Suitable for products labeled 100% organic.
Novation 8300		For moderate temperature/neutral pH applications
Novation 3300		For high temperature/low pH applications
Novation 3600		For high temperature/high shear systems
N-surance		For moderate temperature/high shear applications
Slenderlean		A blend of food starch and maltodextrin to provide ice-cream and frozen desserts with an improved texture and slower melt rate
Novelose 330		Modified tapioca starch in combination with sodium alginate. Provides improvement in tenderness, juiciness and cooking yields without affecting beef flavor in low-fat beef patties
Novelose 260		30% total dietary fiber, white in color, neutral in flavor, with less than 1% fat; contributes to good eating quality and high fiber claims.
N-lite		Contains 60% TDF, the highest level available in a resistant starch. It can be formulated into a broad range of foods such as pasta, cereals and snack foods that can carry a rich-in-fiber labeling.
N-tack		Fat replacer for liquid systems such as spoonable salad dressings, soups and microwavable cheese sauces; provides lubricity without gelling
Dry tack		Waxy cornstarch as an adhesive for cereal-based snack foods. At 30% solids, it exhibits a significantly higher tensile strength than other adhesives. It can be sprayed on at 30–40% solids and develops a tacky texture that dries very quickly.
		Adhere seasonings to snacks without the use of oil or water. It is a free-flowing powder preblended with seasonings and applied while the substrate is hot (250–300 °F). The powder melts in less than 30 s, providing a high degree of tackiness and keeps seasonings attached to the snack.

(continued on next page)

Table 4 (continued)

Trade name of the commercial specialty starch	Name of the company	Description and uses
Textra		Used in hot chocolate to prevent chocolate powder from settling to the bottom of the beverages. It is a tapioca-based specialty starch texturising agent designed to increase body in very thin liquids.
Ultra tex1, ultra perse		Cold-water swelling native maize starches the reconstitution of which have a smooth short texture, good viscosity and creamy mouthfeel. Food applications of Ultra Tex 1 include bakery food fillings, desserts, gravies, soups, sauces and food products subject to frozen storage. Food applications of Ultra-Sperse include refrigerated, frozen and dry food mixes.
HiCap 100		Modified food starch derived from waxy maize, specially suited for the encapsulation of flavors, clouds, vitamins and spices at high oil loading. It is a white fine powder, characterized by excellent resistance to oxidation.
Hylon VII and micro-crisp		High amylose maize flour used in the formulation of breaded foods for deep-frying, oven or microwave cooking.
N-Iok		It is a low-viscosity fine, white powder especially designed for the encapsulation of flavors, fats oils and vitamins, characterized by excellent resistance to oxidation.
Colflo 67		Cross-linked and stabilized starch used in frozen cherry pie filling due to its good freeze-thaw stability.
Ultra set LT		Modified high amylose starch for use in confections, suitable for low temperature processes (140–145 °C).
Hi-set		Modified high amylose starch for use in confections, suitable for use in confections, suitable for jet cooking.
Purity 420 A		Cross-linked and stabilized cornstarch for use in reduced fat spoonable salad dressing formulations.
Struct-sure		Gelatin-replacing starch, to stabilize regular low-fat, no-fat and light yogurts, yielding products with a smooth, creamy texture. Also used to replace milk solids.
Clintose	ADM Food Ingredients	Combination of a pure and stable maltodextrin and crystalline fructose to reduce calories and maintain sweetness in snack foods.
Paselli excel	Avebe America Inc., NJ	Potato-based enzymatically converted product i.e. maltodextrin which forms gels composed of microparticles of 1–2 μ m, that are smooth and creamy. A minimum of 18% is required to form a gel; DE <3 is used for frozen desserts, soups, sauces, dressings and dips, dairy products and bakery products.
Pure cote	Grain Processing Corporation, Muscatine, IA	Corn-based modified starch that acts as an undercoat in panned candies or as a surface shine on chocolate. Preparations of 15–25% in water, cooked at 180 °F for 10 min, and then cooled are required. Maltodextrin, sugar and possibly corn syrups are added to increase solids and facilitate drying.
Pure cote B792		Pregelatinized aqueous-based coating starch that produces clear, flexible films without heating to hydrate the starch, so delicate seasonings and flavors may be added without loss of flavor. The starch has an ability to adhere to large particulates such as sesame, caraway and poppy seeds.
Inscosity		A cold-water swelling starch that provides viscosity without heating/cooking and without forming undesirable lumps or fish-eyes. It is a fine, off-white to cream color powder, that provides freeze-thaw stability without syneresis.
Pen plus 205	Penford Food Ingredients Co., Englewood	Extends shelf life of baked goods due to high moisture-binding properties.
Pen BIND 1000, PenCling 510		Starches are designed for foods requiring a cook-up starch
Hi-Maize	(Starch Australasia) Penford Australia Ltd	Rich in resistant starch, added to foods such as bread, buns, breakfast cereals, pasta, extruded foods, snack, biscuits and drinks without adversely affecting the organoleptic properties. Results in a soft high fiber white bread (Wonder White™) with excellent keeping qualities.
Inamalt 110	Industrializadora de Maiz, S.A. de C.V.	Maltodextrin of DE 10, for use in dry mixes. It is a fine white powder obtained by enzymatic hydrolysis of gelatinized starch suspensions used as fillers/carriers/bulking agents in confectionery products, desserts, bread products, and meat products.
Waxysol		Modified waxy corn starch used as a thickening agent in foods, with great deal of stability under medium and extreme process conditions. The gels of this product present resistance to syneresis during freeze-thaw cycles and minimum opacity; used as a stabilizing agent in formulas for pastry creams, ketchups, puddings, spaghetti sauce, pie filling, bake resistant jellies.
Midsol adhere	Midwest Grain Products, Inc., Atchison	Modified wheat starch with superior binding characteristics for use in batter mixes for breaded, deep-fried foods.
Crysta lean	Opta Food Ingredients, Bedford, MA	Highly retrograded maltodextrin, containing 30% TDF used for reducing calories or increasing fiber especially in baked and extruded products.

(continued on next page)

Table 4 (continued)

Trade name of the commercial specialty starch	Name of the company	Description and uses
Styclor 60	African Products	A medium acid-modified edible maize starch, when heated in water thickens to a peak viscosity that thins with further cooking. On cooling, the solution thickens rapidly and sets to a firm gel; used in confectionery and desserts.
Stygel FS		Pregelatinized starch made from unmodified edible maize starch. It is cold water swelling and commonly used as a thickening agent in puddings, snack foods.
Yellow dextrin stydex specialty dextrin		A low moisture dextrin, derived from the catalytic treatment of maize starch, classed as a thin boiling yellow dextrin, for use in confectionery products.
Maisita 21.050	Agrana Zucker und Stärke AG, Gmuend	Organic corn starch that has very high thickening properties for use in puddings, dessert creams, soups and sauces
Maisita 21.057		Organic waxy maize starch that shows high freeze-thaw stability for use in pudding and dessert cream.
Quemina 21.204		Organic pregelatinized corn starch that yields opaque pastes with high viscosity, for use in instant dough mixes, baking products and pancakes.
Quemina 21.207		Organic pregelatinized waxy maize starch that yields clear smooth paste with high viscosity for use in instant drinks.
Starkina 20.001		Organic potato starch with good water binding capacity and consistency for use in noodles, pasta, bread and snack foods.
Starkina 20.002		Organic potato starch with low moisture content (6%). Due to its low moisture content, this starch is also hygroscopic making it useful as water absorbent in dry mixes. Used in dehydrated soups and sauces (water absorbent), powdered sugar (flow agent) and shredded cheese (for separation).

appropriate coloring and flavoring (Rohwer & Klem, 1984). Fat-free starches have useful properties making gum confections. Granular acid modified starch is treated with methyl alcohol under pressure at 115–150 °C for 30 min to reduce the fat content to 0.09%. It produces gumdrops of superior characteristics (Radley, 1976).

Oxidized starches increase paste clarity but have reduced gel strength; this makes it suitable for tender gum confection of high clarity (Osman, 1984).

High amylose cornstarch containing 70% amylose makes it a strong gelling agent in the manufacture of fine jelly gum candies. It is used in combination with normal fluidity cornstarch (thin boiling starch) in 1:1 ratio to obtain quick setting candy piece with an attractive texture. High amylose starches in jellies and gums result in fast setting that reduces drying time (Cowburn, 1991).

Jelly gum confections with high gel strength after setting comprises 25–99% acid- or enzyme-converted high

Table 5

Digestibility of various modified starches used in snack foods

Starches	Digestibility
WPI-CMS conjugate (Makoto et al., 1995)	Most indigestible with both α -amylase and β -amylase. The conjugation endows CMS with the characteristics of an indigestible polysaccharide
Oxidized starch (WHO, 1972)	Digestibility of hypochlorite-oxidized starch in vivo is similar to that of unmodified starch
Starch acetate (WHO, 1972)	Starch acetate containing 2.5% acetyl groups are only 93.7% as digestible as native starch. Digestibility by fungal amyloglucosidase is 68–81% of that of native starch. The digestibility of starch acetate containing 1.98% acetyl groups by pancreatin and porcine mucosal enzymes is 90% of that of the unmodified starch.
Hydroxypropyl starch (WHO, 1972)	At 0.04 DS, in vitro digestibility by pancreatin is found to be 80% of that of unmodified starch.
Hydroxypropyl distarch glycerol (WHO, 1972)	At 0.04 DS, in vitro digestibility by pancreatin is found to be 86% of that of unmodified starch.
Distarch phosphate (WHO, 1972)	In vitro digestibility by pancreatin of corn or potato starch modified with 0.05 or 0.1% POCl ₃ is found to be similar to unmodified starch. The in vitro digestibility by amyloglucosidase of starch modified with 0.35, 0.07 or 0.1% POCl ₃ varies between 96.4 and 98.3%.
Phosphated distarch phosphate (WHO, 1972)	In vitro digestibility by pancreatic amylase or by pancreatin and porcine intestinal mucosa is somewhat reduced compared with the unmodified starch.
Acetylated distarch phosphate (WHO, 1972)	In vitro digestibility by pancreatin and porcine mucosal enzymes of acetylated distarch phosphates, modified to 1.6 and 2.3% acetyl content are found to be 93 and 81%, respectively, of that of unmodified starch.
Distarch glycerol (WHO, 1972)	In vitro digestibility by amyloglucosidase is 98.3% of that of unmodified starch.
Acetylated distarch glycerol (WHO, 1972)	At 1.2% acetylation, some 82% of the modified starch is digestible, at 2.5, 68.5% is hydrolyzed enzymatically.
Acetylated distarch adipate (WHO, 1972)	In vitro digestibility by amyloglucosidase is 98.3%.
Starch octenyl succinate (Wolf, Thomas, Wolever, Bradley, Keith, & Jeffrey, 2001)	In vitro digestibility by α -amylase and glucoamylase is 70%.

amylose (65–80%) starch and 1–75% of a starch having greater than 25% amylose content, the latter starch being an unconverted starch or a converted starch other than acid- or enzyme-converted high amylose starch (Lacourse & Zallie, 1988). Tapioca specialty dextrins replace from 20–40% of gum arabic in some hard gum candies. Short chain amylose prepared by enzymatic debranching of starch is useful in jelly gum confections as improved gelling agents (Chiu, 1989).

3.29. Starches for chip-like fried snack snacks (Lachmann, 1969b)

Table 3 summarizes various combinations of starches to produce chip-like fried snacks.

4. Commercial specialty starches

A list of the commercially available modified starches suitable for snack foods is compiled in Table 4.

5. Biochemical aspects

This is mainly related to the digestibility of the starches. The information for the various modified starches is compiled in Table 5.

6. Conclusion

With the growth of the processed food industry, the demand for specialty starches should increase. Specialty starches can provide a number of functional benefits to snack foods, and that use is likely to increase due to demand for tasty and appealing reduced fat products. The starch-based coating provides a lot of benefits, including cost effectiveness due to low use level, good flavor release, compatibility with a range of processes, and friendly labeling as corn syrup solids. Commercially developed RS opens up new opportunities for snack manufacturers to develop high-quality fiber-fortified snack products.

The myriad functionality of starches today all but guarantees that—whatever the desired end result—a starch is available to meet the demand. But from the complex combination of applications, possible end-product attributes and processing demands, guidance is needed to exploit this ingredient to the fullest.

7. Future prospects

The future may see an emphasis on new methods of using starch rather than the proliferation of derivatives. That means a focus on physical processes or investigating

possible synergistic relationships that alter the starch characteristics, rather than using chemical modification. Physical modification will become a popular approach to simplifying the label, while offering new functionality.

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