Anexo 1

Cuestionario de Grupos focales

Diversidad de tipos de maíz de la comunidad
¿Qué maíces siembran ustedes?
¿Qué otros maíces conocen ustedes que se siembran en su comunidad?
¿Conocen algunos maíces que se sembraban antes en su comunidad y ya no?
¿Qué otros maíces conocen ustedes que no son de la comunidad?

Especificaciones de cada tipo de maíz
¿Cuáles son los maíces que se siembran más? (más importantes)
¿Cuánto siembran de estos maíces?
¿Los maíces que siembran en mayor cantidad han sido los mismos desde que ustedes eran jóvenes?
¿Desde cuándo tienen estos maíces?
¿Dónde y con quien los consiguieron?

Propiedades que se adjudican a los maíces más importantes
Este maíz es mejor/igual/peor:
Suelo_ en algún tipo de suelo
Región_ en algún lugar o región
Precocidad_ para siembras tempranas o tardías
Resistencia temporal_ aguanta mejor la sequía/lluvia/granizo/helada
Resistencia al acame_ se acama menos
Rendimiento_ rinde más que otros, siempre da bien
Usos_ es mejor para tortillas/tamales/pozol/atole u otro producto
Usos especiales_ tiene un uso especial que solo se puede hacer con este tipo de maíz

Maíces que ya se perdieron
¿Porque ya no se siembra?

Maíces que se conocen de otro lugar
¿Porque no lo siembran?

Cambios en su maíz
¿Ha cambiado su maíz?
¿Porque?
¿Desde cuándo cambió?

Anexo 2 Encuesta sobre diversidad, uso y preferencias de consumo para pobladores de comunidades en estudio

1. IDENTIFICACIÓN

1.1 Datos de cuestionario

(101) Clave única:	(102) Fecha:	
(103) Encuestador:	(104) Comunidad:	(105) Barrio:

1.2 Datos del informante

1.2.1 Nombre:			1.2.2 Sexo:(106)
1.2.3 Edad:(107)	1.2.4Etnia:(108)	1.2.5Habla español:(109)	
1.2.6 Habla lengua indígena:(110)	1.2.7 Cual lengua indígena habla:(111)		
1.2.8 Escolaridad: (112)	1.2.9 Edo. Civil:(113)	1.2.10 Lugar en familia:(114)	

Clave

1.2.2	1:masculino, 2: femenino
1.2.8	1:último año primaria , 2:primaria, 3: último año secundaria, 4:secundaria, 5: último año preparatoria, 6:preparatoria, 7: último año universidad, 8:universidad, 9: ninguna
1.2.9	1:soltero(a), 2: casado(a)
1.2.10	1:padre, 2:madre, 3:hijo, 4:hija, 5:abuelo, 6:abuela

2. DIVERSIDAD Y ORIGEN DE MAÍCES SEMBRADOS POR GRUPO DOMÉSTICO

2. ¿Cuántos tipos de maíz sembró usted el año pasado?

2.1	Clave de muestra	1(200)	2(200)	3(200)	4(200)
2.2	Nombre local	(204)	(204)	(204)	(204)
2.3	Color	(205)	(205)	(205)	(205)
2.4	Lugar de procedencia	(206)	(206)	(206)	(206)
2.5	Tipo de semilla	(207)	(207)	(207)	(207)
2.6	Cantidad de semilla que sembró	(208)	(208)	(208)	(208)
2.7	Fecha en que sembró	(209)	(209)	(209)	(209)
2.8	Fecha en que cosechó	(210)	(210)	(210)	(210)
2.9	Rendimiento obtenido	(211)	(211)	(211)	(211)
2.10	Años sembrando el tipo de semilla	(212)	(212)	(212)	(212)
2.11	Con quien obtuvo la semilla	(213)	(213)	(213)	(213)
2.12	Años sembrando la misma semilla sin cambiarla	(214)	(214)	(214)	(214)

2.13	Ha perdido este tipo de semilla	(215)	(215)	(215)	(215)
2.14	Ha mezclado la semilla	(216)	(216)	(216)	(216)
2.15	Con cual semilla mezcló	(217)	(217)	(217)	(217)

Clave

2.3	1:blanco, 2:blanco cremoso, 3:amarillo claro, 4:amarillo, 5:amarillo obscuro, 6:naranja, 7:rojo claro, 8:rojo, 9:rojo oscuro, 10:azul, 11:azul oscuro, 12:negro, 13:rosa, 14:café, 15:pinto (especificar colores) 16:variegado (especificar colores)
2.4	1:de la comunidad, 2:otra comunidad cercana, 3:tienda local, 4:mercados de fuera, 5:otra región, 6:entrega de un técnico promotor
2.5	1:nativo, 2:mejorado, 3:acriollado
2.11	1: Padre o madre; 2: Otro familiar; 3: Vecino; 4: Agricultor otra comunidad; 5: Comercio misma comunidad; 6:Comercio otra comunidad; 7: Comercio Central de abastos
2.15	1:otro nativo de la comunidad, 2: mismo tipo otro color, 3:nativo de otra región, 4:híbrido

3. IMPORTANCIA Y SATISFACCION DE LOS CARACTERES DE SUS MAICES

3.1Caracteres ambientales

¿Qué tan importante es para usted que su maíz...? , ¿Cuál de sus maíces es mejor en…?

Caracteres		3.1.1 Importancia	3.1.2 Satisfacción con tipo de maíz				
			1	2	3	4	Híbrido
3.1.3	De bien en clima frío	(301)	(301)	(301)	(301)	(301)	(301)
3.1.4	De bien en clima templado	(302)	(302)	(302)	(302)	(302)	(302)
3.1.5	De bien en clima semi-cálido	(303)	(303)	(303)	(303)	(303)	(303)
3.1.6	De bien en clima cálido	(304)	(304)	(304)	(304)	(304)	(304)
3.1.7	De bien en suelo delgado	(305)	(305)	(305)	(305)	(305)	(305)
3.1.8	De bien en suelo profundo	(306)	(306)	(306)	(306)	(306)	(306)
3.1.9	De bien en suelos apretados	(307)	(307)	(307)	(307)	(307)	(307)
3.1.10	De bien en suelos sueltos	(308)	(308)	(308)	(308)	(308)	(308)
3.1.10	Conviene en terreno plano	(309)	(309)	(309)	(309)	(309)	(309)
3.1.12	Conviene en terreno de ladera	(310)	(310)	(310)	(310)	(310)	(310)

Clave

3.1.1	1:muy importante, 2:algo importante, 3:no importante	3.1.2	1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

3.2 Caracteres agrícolas
¿Qué tan importante es para usted...de su maíz? , ¿Cómo es su maíz en…?

Caracteres		3.2.1Importancia	3.2.2 Satisfacción				
			1	2	3	4	Híbrido
3.2.3	Rendimiento en peso del grano	(320)	(320)	(320)	(320)	(320)	(320)
3.2.4	Rendimiento en volumen del grano	(321)	(321)	(321)	(321)	(321)	(321)
3.2.5	Tiempo de maduración largo	(322)	(322)	(322)	(322)	(322)	(322)
3.2.6	Tiempo de maduración intermedio	(323)	(323)	(323)	(323)	(323)	(323)
3.2.7	Tiempo de maduración corto	(324)	(324)	(324)	(324)	(324)	(324)
3.2.8	Resistencia a sequía	(325)	(325)	(325)	(325)	(325)	(325)
3.2.9	Resistencia al frío	(326)	(326)	(326)	(326)	(326)	(326)
3.2.10	Resistencia a granizo	(327)	(327)	(327)	(327)	(327)	(327)
3.2.11	Resistencia a viento	(328)	(328)	(328)	(328)	(328)	(328)
3.2.12	Resistencia a gusano cogollero	(329)	(329)	(329)	(329)	(329)	(329)
3.2.13	Resistencia a gallina ciega	(330)	(330)	(330)	(330)	(330)	(330)
3.2.14	Resistencia a plagas de almacén	(331)	(331)	(331)	(331)	(331)	(331)
3.2.15	Facilidad de desgrane	(332)	(332)	(332)	(332)	(332)	(332)
3.2.16	Saber cómo se siembra y el cuidado del maíz	(333)	-	-	-	-	-

Clave

3.2.1	1:muy importante, 2:algo importante, 3:no importante	3.2.2	1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

3.3 Caracteres morfológicos
¿Qué tan importante es para usted… en su maíz? , ¿Cómo es su maíz en…?

Caracteres		3.3.1Importancia	3.3.2Satisfacción				
			1	2	3	4	Híbrido
3.3.3	Altura de la planta	(340)	(340)	(340)	(340)	(340)	(340)
3.3.4	Grosor del tallo de la planta	(341)	(341)	(341)	(341)	(341)	(341)
3.3.5	Altura de la mazorca	(342)	(342)	(342)	(342)	(342)	(342)
3.3.6	Largo de mazorca	(343)	(343)	(343)	(343)	(343)	(343)
3.3.7	Ancho de mazorca	(344)	(344)	(344)	(344)	(344)	(344)
3.3.8	Número de hileras	(345)	(345)	(345)	(345)	(345)	(345)
3.3.9	Grosor de olote	(346)	(346)	(346)	(346)	(346)	(346)
3.3.10	Tamaño de totomoxtle	(347)	(347)	(347)	(347)	(347)	(347)

3.3.11	Color de totomoxtle	(348)	(348)	(348)	(348)	(348)	(348)
3.3.12	Tamaño del grano	(349)	(349)	(349)	(349)	(349)	(349)
3.3.13	Ancho del grano	(350)	(350)	(350)	(350)	(350)	(350)
3.3.14	Color del grano	(351)	(351)	(351)	(351)	(351)	(351)

Clave

3.3.1	1:muy importante, 2:algo importante, 3:no importante	3.3.2	1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

3. 4 Caracteres de uso

¿Qué tan importante es el uso de su maíz en...? , ¿Cómo es su maíz para …?

Caracteres		3.4.1Importancia	3.4.2Satisfacción				
			1	2	3	4	Híbrido
3.4.3	Grano para forraje	(360)	(360)	(360)	(360)	(360)	(360)
3.4.4	Planta de maíz seca para forraje	(361)	(361)	(361)	(361)	(361)	(361)
3.4.5	Planta de maíz seca como abono	(362)	(362)	(362)	(362)	(362)	(362)
3.4.6	Alimentos	(363)	(363)	(363)	(363)	(363)	(363)
3.4.7	Alimentos tradicionales	(364)	(364)	(364)	(364)	(364)	(364)
3.4.8	Envoltura de tamal	(365)	(365)	(365)	(365)	(365)	(365)
3.4.9	Medicinal	(366)	(366)	(366)	(366)	(366)	(366)
3.4.10	Combustible	(367)	(367)	(367)	(367)	(367)	(367)
3.4.11	Artesanía	(368)	(368)	(368)	(368)	(368)	(368)
3.4.12	Material para la construcción	(369)	(369)	(369)	(369)	(369)	(369)
3.4.13	Masa para llevar al cerro	(370)	(370)	(370)	(370)	(370)	(370)
3.4.14	Mazorcas para poner en el altar de casa	(371)	(371)	(371)	(371)	(371)	(371)
3.4.15	Mazorcas para llevar a la iglesia	(372)	(372)	(372)	(372)	(372)	(372)
3.4.16	Maíces para adivinar	(373)	(373)	(373)	(373)	(373)	(373)

Clave

3.4.1	1:muy importante, 2:algo importante, 3:no importante	3.4.2	1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

4. PREFERENCIA DE CONSUMO DE SUS MAICES

¿Qué tan importante es su maíz ...? , ¿Cómo es su maíz para …?

Calidad		4.1Importancia	4.2Satisfacción				
			1	2	3	4	Híbrido
4.3	por contenido nutricional	(401)	(401)	(401)	(401)	(401)	(401)

4.4	para nixtamal	(402)	(402)	(402)	(402)	(402)	(402)
4.5	para tortilla	(403)	(403)	(403)	(403)	(403)	(403)
4.6	para atole	(404)	(404)	(404)	(404)	(404)	(404)
4.7	para tamales	(405)	(405)	(405)	(405)	(405)	(405)
4.8	para tostadas	(406)	(406)	(406)	(406)	(406)	(406)
4.9	para pinole	(407)	(407)	(407)	(407)	(407)	(407)
4.10	para empanada	(408)	(408)	(408)	(408)	(408)	(408)
4.11	para pozole	(409)	(409)	(409)	(409)	(409)	(409)
4.12	para molotes	(410)	(410)	(410)	(410)	(410)	(410)
4.13	para picaditas (memelitas)	(411)	(411)	(411)	(411)	(411)	(411)
4.14	para totopos	(412)	(412)	(412)	(412)	(412)	(412)
4.15	para elote	(413)	(413)	(413)	(413)	(413)	(413)
4.16	¿Característica de este maíz que lo hace mejor para preparar los alimentos?		(414)	(414)	(414)	(414)	(414)
4.17	¿Propiedad que le brinda este maíz a los alimentos?		(415)	(415)	(415)	(415)	(415)

Clave

4.1	1:muy importante, 2:algo importante, 3:no importante
4.2	1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente
4.16	1:color del grano, 2:tamaño del grano, 3:dureza del grano, 4:sabor del grano, 5: otro_____
4.17	1: color, 2:sabor, 3: olor, 4: espesor, 5 :turgencia, 6: otro_____

5. CARACTERES DE MAICES PARA USOS ESPECIALES

¿Qué tan importante es el uso de su maíz ...? , ¿Cómo es su maíz para …?

Calidad		5.1 Importancia	5.2Satisfacción				
			1	2	3	4	Híbrido
5.3	para segueza	(501)	(501)	(501)	(501)	(501)	(501)
5.4	para nicuatole	(502)	(502)	(502)	(502)	(502)	(502)
5.5	para tejate	(503)	(503)	(503)	(503)	(503)	(503)
5.6	para tepache	(504)	(504)	(504)	(504)	(504)	(504)
5.7	para tlayuda	(505)	(505)	(505)	(505)	(505)	(505)
5.8	para blanditas	(506)	(506)	(506)	(506)	(506)	(506)
5.9	para tortilla de maíz nuevo	(507)	(507)	(507)	(507)	(507)	(507)
5.10	para totopos	(508)	(508)	(508)	(508)	(508)	(508)
5.11	para totopos de maíz nuevo	(509)	(509)	(509)	(509)	(509)	(509)
5.12	para tostadas de corozo	(510)	(510)	(510)	(510)	(510)	(510)

5.13	para tostadas de coco	(511)	(511)	(511)	(511)	(511)	(511)
5.14	para jitapa'a	(512)	(512)	(512)	(512)	(512)	(512)
5.15	para machacado	(513)	(513)	(513)	(513)	(513)	(513)
5.16	para atole de granillo	(514)	(514)	(514)	(514)	(514)	(514)
5.17	para atole de boda (de pinol)	(515)	(515)	(515)	(515)	(515)	(515)
5.18	para chocolate atole	(516)	(516)	(516)	(516)	(516)	(516)
5.19	para dulce de chilacayota	(517)	(517)	(517)	(517)	(517)	(517)
5.20	para a atole de pitiona (temazcal)	(518)	(518)	(518)	(518)	(518)	(518)
5.21	para pozole	(519)	(519)	(519)	(519)	(519)	(519)
5.22	¿Característica de este maíz que lo hace mejor para preparar los alimentos?		(520)	(520)	(520)	(520)	(520)
5.23	¿Propiedad que le brinda este maíz a los alimentos?		(521)	(521)	(521)	(521)	(521)

Clave

5.1	1:muy importante, 2:algo importante, 3:no importante
5.2	1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente
5.22	1:color del grano, 2:tamaño del grano, 3:dureza del grano, 4:sabor del grano, 5: otro_____
5.23	1: color, 2:sabor, 3: olor, 4: espesor, 5 :consistencia, 6: otro_____

6. MANEJO DEL CULTIVO

¿Hace alguna actividad diferente durante el ciclo del cultivo para algún maíz?

6.1	Clave de muestra	6.2	Actividad
(200)		(601)	

7. MAÍCES QUE SE CONOCEN Y NO SE SIEMBRAN

¿Qué otros maíces conoce que usted no siembra?

7.1	Clave de tipo de maíz	1(701)	2(701)
7.2	Nombre local	(703)	(703)
7.3	Color	(704)	(704)
7.4	Lugar de procedencia	(705)	(705)
7.5	Porque no se siembra	(706)	(706)
7.6	Que le interesa de la variedad	(707)	(707)

Clave

7.3	1:blanco, 2:blanco cremoso, 3:amarillo claro, 4:amarillo, 5:amarillo obscuro, 6:naranja, 7:rojo claro, 8:rojo, 9:rojo oscuro, 10:azul, 11:azul oscuro, 12:negro, 13:rosa, 14:pinto (especificar colores) 15:variegado (especificar colores)

7.4	1:de la comunidad, 2:comunidad cercana, 3:otra región del estado, 4:otro estado
7.5	1:porque no se consigue semilla, 2:porque no crece en el clima, 3:porque no rinde, 4:porque no se usa mucho, 5:porque no conviene el tiempo de maduración, 6:Porque no dio tiempo de sembrarlo, 7: porque no hay recurso para sembrar más tipos
7.6	1:tiempo de maduración, 2:el color del grano, 3:calidad forrajera, 4:el tamaño de la mazorca, 5:la altura de la planta, 6:el peso del grano, 7: el totomoxtle

8. MAÍCES QUE SE HAN PERDIDO

¿Qué maíces se han perdido en la comunidad?

8.1	Clave del tipo de maíz	1(801)	2(801)
8.2	Nombre local	(803)	(803)
8.3	Color	(804)	(804)
8.4	Lugar de procedencia	(805)	(805)
8.5	Porque se dejó de sembrar	(806)	(806)
8.6	Existe en la región	(807)	(807)

Clave

8.3	1:blanco, 2:blanco cremoso, 3:amarillo claro, 4:amarillo, 5:amarillo obscuro, 6:naranja, 7:rojo claro, 8:rojo, 9:rojo oscuro, 10:azul, 11:azul oscuro, 12:negro, 13:rosa, 14:pinto (especificar colores) 15:variegado (especificar colores)
8.4	1:de la comunidad, 2:comunidad cercana, 3:otra región del estado, 4:otro estado
8.5	1:porque no se consigue semilla, 2:porque no da bien en el clima, 3:porque no rinde, 4:porque no tiene muchos usos, 5:por la altura de la planta

9.FAMILIAR

9.1 Área agrícola

9.1.1	Tipo de acceso a la tierra	(901)	9.1.5	Con quien comparte área productiva	(905)
9.1.2	Tipo de propiedad de la tierra	(902)	9.1.6	Con quien se organiza para las actividades del campo	(906)
9.1.3	Con que cantidad de tierra cuenta	(903)	9.1.7	De quien es la mano de obra en el cultivo	(907)
9.1.4	Usted comparte área productiva	(904)	9.1.8	Cuenta con riego que se use en cultivo de maíz	(908)

Clave

9.1.1	1:propietario, 2:a medias, 3:renta, 4: terreno prestado, 5:propietario y renta
9.1.2	1:ejidal, 2:comunal
9.1.5	1:padre (madre), 2:hermano (a), 3:hijo (a), 4:dueño (a), 5:vecino(a)
9.1.6	1:padre (madre), 2:esposo (a), 3:hermano (a), 4:hijo (a), 5:dueño (a)
9.1.7	1:familiar, 2:jornaleros, 3:más familiar y pocos jornales, 4:más jornales y poco familiar
9.1.8	1:con acceso, 2:sin acceso

9.2 Residencia familiar y consumo

9.2.1	Familias que habitan en el mismo lote	(920)	9.2.9	Cuánto de la cosecha es para los animales	(928)

9.2.2	Familias que comparten los alimentos al día	(921)	9.2.10	Cuánto de la cosecha es para vender	(929)
9.2.3	Integrantes adultos de la familia que viven en casa	(922)	9.2.11	Cuánto compra de maíz en el año	(930)
9.2.4	Integrantes niños de la familia que viven en casa	(923)	9.2.12	% de ingreso proveniente de jornales	(931)
9.2.5	Todos en la familia hablan lengua indígena	(924)	9.2.13	% de ingreso proveniente de trabajo no agrícola	(932)
9.2.6	Cuántas mujeres monolingües hay en la familia	(925)	9.2.14	% de ingreso proveniente de negocio propio	(933)
9.2.7	Escolaridad máxima de algún miembro de la familia	(926)	9.2.15	% de ingreso proveniente de remesas de E. U	(934)
9.2.8	Cuánto de la cosecha es para consumo familiar	(927)	9.2.16	% de ingreso proveniente de remesas de otras partes de México	(935)

Clave

9.2.5	1:si. 2:no, especificar cuantos y quienes
9.2.7	1:último año primaria , 2:primaria, 3: último año secundaria, 4:secundaria, 5: último año preparatoria, 6:preparatoria, 7: último año universidad, 8:universidad

9.3Vivienda

9.3.1	Número de cuartos en casa	(940)	9.3.8	Tiene lavadora	(947)
9.3.2	De qué material son las paredes	(941)	9.3.9	Tiene microondas	(948)
9.3.3	De qué material es el techo	(942)	9.3.10	Qué tipo de sanitario tiene	(949)
9.3.4	De qué material es el piso	(943)	9.3.11	Tiene teléfono fijo	(950)
9.3.5	Hay agua potable en casa	(944)	9.3.12	Cuántos en la familia poseen teléfono celular	(951)
9.3.6	Se cuenta con vehículo	(945)	9.3.13	Tiene computadora	(952)
9.3.7	Tiene refrigerador	(946)	9.3.14	Cuenta con internet	(953)

Clave

9.3.2	1:adobe, 2:tabique, 3:madera, 4:bajareque, 5:otro_____, 6: combinación (especificar)_____
9.3.3	1:teja, 2:loza, 3:lámina metal, 4:lámina cartón, 5:otro_____, 6: combinación (especificar)_____
9.3.4	1:cemento, 2:tierra, 3:loseta, 4:otro_____, 5: combinación (especificar)_____
9.3.10	1:ninguno, 2:letrina, 3:letrina seca, 4:WC

9.4Tradición familiar

9.4.1	Ha participado o tiene algún cargo en la comunidad	(960)	9.4.5	Cada cuando van los niños a la milpa	(964)
9.4.2	Ha participado o tiene mayordomía	(961)	9.4.6	Hizo rezos en el terreno de siembra el año pasado	(965)
9.4.3	Las mujeres de casa usan vestimenta regional	(962)	9.4.7	Llevó a bendecir sus mazorcas a la iglesia el año pasado	(966)
9.4.4	Los hombres de casa usan vestimenta regional	(963)	9.4.8	Acostumbra ir a pedir o dar gracias al cerro	(967)

Clave

9.4.1, 9.4.2	1: si, 2: no, especificar cual
9.4.3	1:diario, 2: en eventos especiales
9.4.5	1:diario, 2:una vez a la semana, 3:una vez al mes, 4:en temporada vacacional, 5:en la siembra, 6:en la cosecha , 7: no asisten

Anexo 3. Importancia de las características de los maíces en cada comunidad.

Comunidad	Variante de maíz	F	C	S	CN	RA	RB	P	M	G	U	UC	U A	AC	AE	I
Atempa	Zapalote chico blanco	30	1.6	3.1	2.1	2.0	1.1	2.8	5.1	3	4.1	0.4	3	6.5	6.9	41.1
Puerto	Olotillo amarillo	9	1.1	3.9	2	1.0	2.5	2.1	5.0	2.6	3.8	1.2	2.9	8.0	7.2	43.6
	Tuxpeno amarillo	9	1.1	3.9	2.2	1.1	2.3	2.2	4.9	2.5	4.5	0.6	2.8	8.2	8.7	45.4
	Tuxpeno blanco	29	1.1	3.6	2.1	1.1	1.3	2.1	3.8	2.4	3.9	0.8	2.6	8.1	8.9	42.0
	Conejo amarillo	3	1.1	3.6	2.2	1.7	1.4	0.8	2.6	1.8	3.4	0.5	2.8	7.7	6.7	36.3
	Conejo blanco	3	0.9	3.3	1.9	1.7	0.5	1.7	3.1	1.7	3.6	1.3	2.5	8.0	11.6	41.6
	Hibrido blanco	3	1.2	4.9	2.4	1.1	2.2	2.3	4.2	2.5	3.3	0.5	2.7	7.5	6.3	41.0
	Olotillo blanco	3	1.2	4.0	1.6	-0.1	1.8	2.3	4.9	3.0	4.5	0.7	2.8	8.7	8.2	43.5
	Tepecintle blanco	1	1.0	3.6	2.7	0.5	2.0	1.5	3.0	3.0	5.4	0.0	3.0	7.5	12.5	45.7
	Olotillo negro	1	0.7	4.4	2.1	1.2	2.4	3.0	5.0	3.0	4.2	0.0	3.0	3.0	4.0	36.0
	Tuxpeno negro	1	1.2	3.8	2.3	1.0	1.5	2.0	4.0	2.5	2.9	0.0	2.5	6.0	3.3	33.0
	Olotillo pinto	2	1.2	3.7	2.0	1.5	1.8	2.5	4.3	2.8	4.0	1.2	2.5	9.0	9.0	45.3
	Tuxpeno pinto	2	1.3	3.8	2.1	0.6	1.9	2.0	3.8	3.0	3.9	1.0	3.0	8.5	8.8	43.5
	Olotillo rojo	1	0.6	2.9	-0.6	0.5	1.0	1.5	6.0	3.0	4.3	1.0	3.0	0.0	8.4	31.6
	Tuxpeno rojo	2	1.5	3.7	2.2	0.6	1.8	1.8	4.8	3.0	2.9	0.0	3.0	7.8	5.9	38.7
	Tuxpeno variegado	2	1.4	3.5	2.2	0.6	1.3	1.8	4.0	2.8	3.4	0.0	2.8	7.5	5.2	36.2
Jicayán	Conejo amarillo	10	0.8	2.4	1.7	0.9	1.4	2.1	3.9	2.5	3.7	0.3	2.7	6.8	7.1	36.3
	Olotillo amarillo	18	1.4	3.3	2.4	1.3	1.7	2.3	4.2	2.6	4.2	0.8	2.4	7.0	7.3	40.9
	Olotillo blanco	28	1.3	3.0	2.2	1.4	1.2	2.2	4.4	2.7	3.7	0.7	2.6	8.2	8.5	41.9
	Tuxpeno blanco	9	1.2	2.9	1.9	1.7	1.5	2.4	4.4	2.6	3.5	0.4	2.7	8.7	9.3	43.2
	Olotillo negro	11	1.2	2.7	2.2	1.1	0.8	1.7	3.1	2.4	3.3	0.5	2.5	6.9	3.2	31.6
	Olotillo rojo	9	1.0	3.0	2.5	1.1	1.9	2.2	4.0	2.4	3.8	1.2	2.6	6.0	5.1	36.8
	Tuxpeno amarillo	3	1.4	3.0	1.6	1.4	1.4	1.6	3.0	2.1	1.9	0.0	2.7	8.1	5.3	33.6
	Conejo blanco	4	1.5	2.9	2.5	1.7	2.1	2.0	2.3	1.3	2.8	0.5	1.4	6.3	8.2	35.3
	Conejo negro	5	1.2	3.6	1.3	0.5	0.7	1.9	3.5	2.1	3.2	1.0	2.7	5.4	4.5	31.7
	Tuxpeno negro	2	1.6	2.7	2.2	1.4	1.5	2.7	3.2	2.8	3.4	0.2	2.8	8.5	4.4	37.2
	Conejo pinto	1	1.0	3.2	3.4	2.0	2.5	1.6	3.5	2.5	2.2	0.0	3.0	7.3	2.4	34.6
	Olotillo pinto	3	1.5	3.5	2.1	1.6	1.4	1.8	4.3	2.2	4.9	1.2	2.3	5.6	2.2	34.6
	Conejo rojo fuerte	1	1.0	3.6	1.4	2.0	-0.9	2.2	4.8	2.2	0.8	-0.8	1.8	7.6	6.4	32.1
	Tuxpeno rojo	4	1.2	3.9	2.3	2.0	1.5	2.4	4.0	2.6	4.3	0.3	2.8	7.8	9.0	43.9
	Conejo variegado	1	1.0	3.2	2.2	0.9	1.5	2.0	1.7	2.2	4.0	1.0	3.0	8.0	8.0	38.7
Yatareni	Bolita amarillo	5	1.1	3.4	2.4	2.1	2.3	2.5	4.0	3.0	4.3	1.2	2.6	8.3	6.1	43.4
	Bolita blanco	21	1.1	3.3	2.1	1.7	2.1	2.7	4.8	3.0	4.0	1.1	2.8	9.3	8.2	46.1
	Bolita negro	1	1.0	3.4	0.9	1.3	1.0	1.5	2.5	1.5	3.2	1.0	2.0	3.0	3.0	25.3
Huayapam	Ancho blanco	4	1.1	3.0	1.9	1.3	2.1	2.4	5.2	3.0	4.4	1.4	2.9	9.3	8.3	46.1
	Bolita blanco	18	1.0	3.3	2.0	1.4	2.1	2.8	4.9	3.0	3.5	0.7	2.9	9.2	8.9	45.7
	Bolita amarillo	7	1.0	2.8	2.1	1.5	2.2	2.6	4.5	2.9	3.6	0.7	3.0	8.9	7.8	43.7
	Bolita negro	2	1.0	3.2	1.9	0.9	2.0	2.1	3.3	3.0	3.3	0.4	2.3	6.8	1.3	31.2

	Bolita pinto	1	1.0	3.0	2.2	2.0	2.0	0.4	4.8	3.0	4.4	0.8	3.0	10.0	9.5	46.1
	Bolita rojo	1	1.0	3.4	3.2	1.5	2.5	3.0	6.0	1.5	3.2	0.4	2.5	10.0	9.5	47.7
Mazaltepec	Bolita amarillo	12	1.4	4.0	2.1	1.8	1.5	2.8	4.5	2.8	4.5	0.2	2.8	7.1	5.7	41.2
	Bolita blanco	27	1.4	4.1	2.1	1.4	1.6	2.7	4.9	2.8	4.1	0.5	2.8	8.9	7.5	44.8
	Hibrido blanco	5	1.4	3.9	2.5	2.7	0.5	2.5	4.1	3.0	3.1	0.3	0.4	1.2	-0.3	25.2
	Bolita negro	8	1.4	4.1	2.0	1.3	1.1	2.6	4.4	2.7	4.1	0.2	2.5	5.7	3.9	35.9
	Bolita pinto	2	2.1	4.6	1.6	1.2	1.5	2.3	3.0	3.0	4.8	0.0	2.8	7.0	5.5	39.1
Peñoles	Bolita blanco	12	1.2	3.0	2.2	1.8	1.7	2.3	5.5	2.9	3.8	0.1	2.9	9.0	6.5	43.0
	Conico blanco	13	1.1	3.1	2.0	1.9	1.8	2.5	4.9	2.9	3.3	0.4	2.6	8.8	5.8	41.1
	Conico amarillo	14	1.2	3.0	2.2	1.7	1.2	2.2	4.4	2.7	3.1	0.3	2.7	7.9	3.9	36.5
	Elotes conicos negro	15	1.0	3.1	2.0	2.0	1.5	2.0	4.3	2.9	3.4	0.1	2.7	7.8	4.3	37.3
	Elotes conicos rojo	11	1.0	3.0	1.8	1.4	1.5	2.3	4.5	2.9	3.0	0.3	2.7	7.6	4.3	36.2
	Ancho blanco	1	0.8	3.0	2.1	2.0	3.0	2.5	5.0	3.0	3.9	0.0	3.0	7.5	6.6	42.4
	Arrocillo blanco	2	1.0	3.0	2.5	2.3	1.8	2.5	4.6	2.8	3.0	0.5	2.8	8.9	5.3	40.7
	Elotes conicos blanco	2	1.0	3.0	1.8	0.5	0.5	2.5	4.5	3.0	3.1	0.2	2.2	7.8	3.9	33.8
	Elotes conicos blanco	2	1.0	3.0	1.8	0.5	0.5	2.5	4.5	3.0	3.1	0.2	2.2	7.8	3.9	33.8
	Tuxpeno blanco	1	0.8	3.0	2.4	2.0	1.5	3.0	5.0	3.0	4.7	0.0	3.0	9.0	5.6	43.0
	Elotes conicos blanco	2	1.0	3.0	1.8	0.5	0.5	2.5	4.5	3.0	3.1	0.2	2.2	7.8	3.9	33.8
	Bolita amarillo	3	1.1	3.0	2.1	1.9	1.8	2.1	4.5	2.8	3.5	0.0	3.0	8.4	5.5	39.7
	Elotes conicos amarillo	1	1.0	3.0	2.3	2.0	2.0	2.5	4.6	2.5	1.6	0.0	3.0	8.0	4.7	37.2
	Bolita negro	2	1.2	3.0	2.2	1.1	1.5	2.4	4.8	3.0	3.1	1.0	2.5	7.6	4.5	37.7
	Conico negro	1	1.0	3.4	2.1	1.7	2.0	2.5	4.5	2.5	2.2	0.0	3.0	7.5	6.7	39.1
	Chalqueno rosa	1	1.0	3.0	2.7	2.5	2.5	2.0	3.5	2.2	4.4	0.0	2.5	7.7	3.3	37.3
	Conico pinto	3	1.0	3.0	2.3	2.2	1.2	2.2	4.3	2.8	3.3	0.2	2.5	7.0	5.0	37.0
	Elotes conicos pinto	1	0.7	3.0	1.4	1.2	2.0	3.0	5.0	2.5	4.6	0.0	3.0	9.0	5.0	40.4
Jaltianguis	Conico blanco	9	0.9	3.4	2.3	2.0	1.5	2.4	4.3	2.8	3.3	1.5	2.9	9.0	5.2	41.3
	Oloton blanco	11	0.5	3.7	2.1	2.2	1.5	2.2	4.5	2.9	3.3	1.5	2.9	9.1	5.1	41.6
	Oloton amarillo	8	0.3	4.1	2.2	2.3	1.5	2.0	5.1	2.7	3.6	1.3	2.9	8.1	4.3	40.3
	Oloton pinto	5	0.9	3.6	2.1	2.2	1.2	2.0	5.0	2.9	4.2	1.3	3.0	8.8	4.7	41.8
	Bolita blanco	2	0.8	3.3	1.7	2.3	1.2	2.0	4.0	2.8	3.1	1.4	3.0	9.0	5.3	39.5
	Hibrido	1	1.0	2.6	2.2	2.0	-0.1	2.2	3.9	3.0	2.4	1.0	3.0	9.0	4.5	36.7
	Nal-tel de altura blanco	1	0.5	3.2	2.5	3.0	1.7	2.5	4.7	3.0	3.9	1.4	3.0	8.9	7.5	45.8
	Conico amarillo	4	0.9	3.4	2.2	1.5	1.6	2.5	4.7	2.9	2.9	2.0	3.0	7.7	4.6	39.7
	Nal-tel de altura amarillo	2	0.8	3.4	1.8	2.3	1.5	2.1	4.6	2.8	4.7	1.0	3.0	9.2	4.5	41.4
	Conico morado	3	1.2	3.3	2.0	2.2	1.5	2.1	4.1	3.0	2.6	1.3	3.0	8.4	4.3	39.1
	Elotes conicos negro	4	0.6	3.3	2.2	1.8	0.9	2.0	4.8	3.0	3.5	1.1	2.6	8.6	4.3	38.6
	Oloton negro	2	0.9	3.8	2.0	2.2	2.5	2.5	5.5	2.8	3.7	1.4	2.8	8.5	5.2	43.6
	Conico pinto	1	-1.0	3.6	0.4	2.5	1.5	2.4	4.9	2.5	2.9	3.0	2.5	8.5	8.0	41.7
	Oloton rojo	3	0.0	4.2	2.7	2.0	0.7	2.1	4.1	3.0	4.6	1.8	3.0	7.3	4.4	39.9
Tlauhitoltepec	Mixeno amarillo	6	0.8	3.4	2.2	2.1	1.1	2.4	5.2	2.9	4.2	2.0	3.0	8.2	6.3	43.9
	Nal-tel de altura amarillo	5	0.6	3.4	1.9	2.0	1.6	2.3	5.2	2.7	5.2	3.2	2.7	8.4	6.8	46.0

	Oloton amarillo	5	0.9	3.4	2.3	2.1	1.6	2.3	5.2	3.0	5.1	3.3	3.0	9.0	7.0	48.1
	Serrano mixe amarillo	9	0.9	2.9	2.1	2.1	1.5	2.2	5.4	2.8	5.3	2.9	3.0	8.0	5.9	45.1
	Serrano mixe blanco	9	1.2	3.4	2.4	2.3	1.4	2.2	5.4	2.9	4.7	2.5	2.9	8.5	6.9	46.6
	Oloton blanco	5	0.9	3.6	2.4	2.1	1.7	2.3	5.0	2.9	5.0	3.3	3.0	9.0	6.6	47.7
	Mixeno blanco	4	1.0	3.2	2.3	2.2	1.5	2.6	5.2	2.9	4.6	2.2	3.0	8.5	7.7	46.8
	Nal-tel de altura blanco	3	1.0	3.8	2.0	1.9	1.8	2.6	5.3	2.5	4.9	2.7	3.0	8.3	6.2	46.0
	Mixeno negro	1	1.0	4.0	2.2	1.5	-0.1	2.5	4.7	3.0	2.5	2.4	3.0	6.5	1.0	34.2
	Nal-tel de altura negro	1	0.5	3.8	1.2	2.5	2.0	2.5	6.4	3.0	5.4	2.2	2.5	7.0	4.5	43.5
	Oloton negro	3	0.6	3.4	1.7	2.0	1.5	2.2	5.7	3.0	4.6	2.8	2.8	8.2	5.8	44.3
	Serrano mixe negro	2	1.0	3.4	2.2	2.5	3.0	1.8	4.1	3.0	4.6	3.4	3.0	8.0	6.0	46.0
	Mixeno pinto	1	2.0	5.0	2.9	1.5	2.5	2.5	5.5	1.5	6.0	3.0	3.0	10.0	7.1	52.5
	Oloton pinto	4	0.5	3.3	2.0	2.1	1.2	2.1	4.9	2.8	5.1	3.5	2.9	7.9	6.7	44.9
	Serrano mixe rojo	2	0.8	3.1	2.3	2.3	0.6	2.4	5.7	2.8	3.9	3.7	2.8	7.8	5.6	43.5

F=Frecuencia; C=Clima; S=Suelo; CN=Conducta; RA=Resistencia ambiental; RB=Resistencia Biológica; P=Caracteres de la planta; M=Caracteres de la mazorca; G=Caracteres del grano; U=Usos generales; UC=Usos ceremoniales; UA=Usos alimenticios; AC=Alimentos comunes; AE=Alimentos especiales; I=índice.

Anexo 4. Encuesta sobre demanda de maíz por las mujeres del grupo doméstico

1.1 Comunidad:_____ 1.2 Fecha:_____

Nombre:_____ 1.3 Edad:_____ 1.4 Estado civil*:_____

1.4_1:casado(a) 2:soltero(a) 3:divorcviado(a) 4:viudo (a)

2. Tipos de maíces que se siembran

2. ¿Qué tipos de maíz sembraron el año pasado?

2.1 No. de tipo de maíz	1(201)	2(202)	3(203)	4 (204)	5 (205)
2.2 Nombre local					
2.3 Color					
2.4 ¿Cuáles de estos pidió usted que se sembraran?					
2.5 ¿Cuáles de estos son de fuera de la comunidad?					
2.6 ¿De dónde vienen los maíces de fuera?					

2.3_1:blanco, 2:blanco cremoso, 3:amarillo claro, 4:amarillo, 5:amarillo obscuro, 6:naranja, 7:rojo claro, 8:rojo, 9:rojo oscuro, 10:azul, 11:azul oscuro, 12:negro, 13:rosa, 14:pinto (especificar colores) 15:variegado (especificar colores)

3. Maíces que ocasionalmente se han sembrado

3. ¿En los últimos 10 años han sembrado otros tipos de maíces?

3.1 No. de tipo de maíz	1 (301)	2 (302)	3 (303)
3.2 Nombre local			
3.3 Color			
3.4 ¿Por qué los han cultivado?			
3.5 ¿De dónde consiguieron las semillas?			
3.6 ¿Quién tomó la decisión de que se sembrara?			
3.7 Si ella pidió algunos ¿Por qué pidió que se sembraran?			

3.4_ 1:de la comunidad, 2:otra comunidad cercana, 3:tienda local, 4:mercados de fuera, 5:otra región del estado, 6:otro estado
3.6_1:él solo, 2:ella sola, 3:ambos, 4:su hijo, 5:su hija, 6:padre e hijo, 7:madre e hijo
3.3_1:blanco, 2:blanco cremoso, 3:amarillo claro, 4:amarillo, 5:amarillo obscuro, 6:naranja, 7:rojo claro, 8:rojo, 9:rojo oscuro, 10:azul, 11:azul oscuro, 12:negro, 13:rosa, 14:pinto (especificar colores) 15:variegado (especificar colores)

4. Maíces en venta

4. ¿Cuáles maíces de los que siembran se venden?

4.1 No. de tipo de maíz	1(201)	2(202)	3(203)	4 (204)	5 (205)
4.2 Nombre local					
4.3 ¿Quién decide que se vendan?					
4.4 En los que ella decidió ¿Por qué conviene vender este maíz?					
4.5 ¿Cuánto vendió el año pasado de este maíz?					

4.3_ 1:él solo, 2:ella sola, 3:ambos, 4:su hijo, 5:su hija, 6:padre e hijo, 7:madre e hijo

5. Maíces que compran

5. ¿Qué maíces compró el año pasado?

5.1 No. de tipo de maíz	1(501)	2(502)	3(503)
5.2 Nombre local			
5.3 Color			
5.4 ¿Cuáles se compraron dentro de la comunidad?			
5.5 ¿En dónde lo compró?			
5.6 ¿Cuáles de estos son de siembra local?			
5.7 ¿Cuáles de estos se trajeron de fuera?			
5.8 ¿Usted sabe de dónde vienen los maíces de fuera?			
5.9 ¿Cuáles se compraron fuera de la comunidad?			
5.10 ¿En dónde lo compró?			
5.11 ¿Usted sabe de dónde son los maíces que se compraron fuera de la comunidad?			
5.12 ¿Cuántas veces ha comprado este maíz al año?			
5.13 ¿Cuánto compro de este maíz el año pasado?			
5.14 ¿En que usa este maíz?			

5.5_ 1:vecino, 2:tienda local,3: Liconsa, 4:revendedor
5.10_ 1:la central, 2:otra comunidad cercana

6 Selección de grano para la preparación de los platillos comunes

6. ¿Qué maíces usa para preparar este platillo?

	6.1maíces sembrados					6.2 maíces comprados			6.10 ¿Cuál le gusta?	6.11 ¿Cuál no le gusta?
	1(201)	2(202)	3(203)	4 (204)	5 (205)	1(501)	2(502)	3(503)		
6.3 Tortilla (blanditas)										
6.4 Tostadas										
6.5 Tamales										
6.6 Atole										
6.7 Elote										
6.8 ¿Característica más apreciada del maíz para elaborar este platillo?										
6.9 ¿Característica no apreciada del maíz para elaborar este platillo?										

6.8 y 6.9:color del grano, 2:tamaño del grano, 3:dureza del grano, 4:sabor del grano

7. Selección de grano para la preparación de los platillos especiales

	7.1 maíces sembrados					7.2 maíces comprados			7.21 ¿Cuál le gusta?	7.22 ¿Cuál no le gusta?
	1(201)	2(202)	3(203)	4 (204)	5 (205)	1(501)	2(502)	3(503)		
7.3 segueza										
7.4 nicuatole										
7.5 tejate										
7.6 tepache										
7.7 tlayuda										
7.8 totopos										
7.9 tostadas de coco o corozo										
7.10 atole de granillo										
7.11 atole de boda										
7.12 chile atole										
7.13 atole de maíz tostado										
7.14 hierbatole										

7.15 tamales de elote										
7.16 pozol										
7.17 pozole con carne										
7.18 pozole de calabaza										
7.19 amarillo										
7.20 ¿Característica más apreciada del maíz para elaborar este platillo?										
7.23 ¿Característica no apreciada del maíz para elaborar este platillo?										

7.20 y 7.23_1:color del grano, 2:tamaño del grano, 3:dureza del grano, 4:sabor del grano

8. ¿Usted compra un maíz para la preparación de algún alimento en específico?

Anexo 5 Encuesta para evaluación de maíces en la preparación de los productos.

1 Datos de identificación

1.1 Comunidad: Santa María Jaltianguis 1.2 Fecha:_____

Nombre:_____ 1.3 Edad:_____1.4 Producto Tortilla

2 Nixtamalización

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) Híbrido
2.1 ¿Cantidad de agua utilizada? (L)				
2.2 ¿Cantidad de cal utilizada? (g)				
2.3 ¿Tiempo de cocción? (hr)				
2.4 ¿Número de lavados?				
2.5 ¿Cómo fue el desprendimiento de pericarpio?				
2.6 ¿Tiempo de reposo? (hr)				
2.7 ¿Satisfacción del nixtamal?				
2.8 Comentarios				

2.5_ 1: muy fácil, 2:fácil, 3:difícil,4:muy difícil
2.7_ 1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

3 Calidad de la masa

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) Híbrido
3.1 ¿Tipo de molienda?				
3.2 ¿Rendimiento? (kg)				
3.3 ¿Satisfacción del color de la masa?				
3.4 ¿Satisfacción del aroma de la masa?				
3.5 ¿Satisfacción de la maleabilidad de la masa?				
3.6 Comentarios				

3.1_ 1: gruesa, 2: intermedia, 3: fina
3.3, 3.4 y 3.5_1: muy bueno, 2: bueno, 3:deficiente, 4:muy deficiente

4 Satisfacción de la variante de maíz en el producto final

4.5 TORTILLA	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) Híbrido
4.5.1 ¿Cómo es el tiempo de cocción con este maíz?				
4.5.2 ¿Cómo es el grosor con este maíz?				
4.5.3 ¿Cómo es la textura suave con este maíz?				
4.5.4 ¿Cómo es el aroma con este maíz?				
4.5.5 ¿Cómo es el color con este maíz?				
4.5.6 ¿Cómo es el rendimiento con este maíz?				
4.5.7 Comentarios				

1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

1.1 Comunidad: San Agustín Yatareni 1.2 Fecha:_____

Nombre: _____ 1.3 Edad:____1.4 Producto: Nicuatole

2 Tlaciahuatl

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) Híbrido
2.1 ¿Cantidad de agua utilizada? (L)				
2.2 ¿Tiempo de cocción? (hr)				
2.3 ¿Satisfacción de coloración del maíz cocido?				
2.4 ¿Satisfacción del tlaciahuatl?				
2.5 Comentarios				

2.3 y 2.4_ 1: muy bueno, 2:bueno, 3:deficiente, 4:muy deficiente

3 Calidad de la masa

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) Híbrido
3.1 ¿Tipo de molienda?				
3.2 ¿Rendimiento? (kg)				
3.3 ¿Satisfacción del color de la masa?				
3.4 ¿Satisfacción del aroma de la masa?				
3.5 ¿Satisfacción de la maleabilidad de la masa?				
3.6 Comentarios				

3.1_ 1: gruesa, 2: intermedia, 3: fina
3.3, 3.4 y 3.5_1: muy bueno, 2:bueno, 3:deficiente, 4:muy deficiente

4 Satisfacción de la variante de maíz en el producto final

4.2 NICUATOLE	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) Híbrido
4.2.1 ¿Cómo es el tiempo de cocción con este maíz?				
4.2.2 ¿Cómo es el cuajado con este maíz?				
4.2.3 ¿Cómo es el color con este maíz?				
4.2.4 ¿Cómo es el rendimiento en nicuatole con este maíz?				
4.2.5 Comentarios				

1: muy bueno, 2:bueno, 3:deficiente, 4:muy deficiente

1.1 Comunidad: Santo Tomas Mazaltepec 1.2 Fecha:_____

Nombre:_____ 1.3 Edad:_____1.4 Producto Tlayuda

2 Nixtamalización

Preguntas	1 (201) Nativo	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) H-377
2.1 ¿Cantidad de agua utilizada? (L)				
2.2 ¿Cantidad de cal utilizada? (g)				
2.3 ¿Tiempo de cocción? (hr)				
2.4 ¿Número de lavados?				
2.5 ¿Cómo fue el desprendimiento de pericarpio?				
2.6 ¿Tiempo de reposo? (hr)				
2.7 ¿Satisfacción del nixtamal?				
2.8 Comentarios				

2.5_ 1: muy fácil, 2:fácil, 3:difícil,4:muy difícil
2.7_ 1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

3 Calidad de la masa

Preguntas	1 (201) Nativo	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) H-377
3.1 ¿Tipo de molienda?				
3.2 ¿Rendimiento? (kg)				
3.3 ¿Satisfacción del color de la masa?				
3.4 ¿Satisfacción del aroma de la masa?				
3.5 ¿Satisfacción de la maleabilidad de la masa?				
3.6 Comentarios				

3.1_ 1: gruesa, 2: intermedia, 3: fina
3.3, 3.4 y 3.5_1: muy bueno, 2: bueno, 3:deficiente, 4:muy deficiente

4 Satisfacción de la variante de maíz en el producto final

4.4 TLAYUDA	1 (201) Nativo	2 (202) Zapalote Chico	3 (203) Comercial	4 (204) H-377
4.4.1 ¿Cómo es el tiempo de cocción con este maíz?				
4.4.2 ¿Cómo es el grosor con este maíz?				
4.4.3 ¿Cómo es la textura con este maíz?				
4.4.4 ¿Cómo es el aroma con este maíz?				
4.4.5 ¿Cómo es el color con este maíz?				
4.4.6 ¿Cómo es el rendimiento con este maíz?				
4.4.7 Comentarios				

1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

1.1 Comunidad: San Blas Atempa 1.2 Fecha: _____

Nombre: _____ 1.3 Edad:____1.4 Producto Totopo

2 Nixtamalización

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Sinaloa	4 (204) H-565
2.1 ¿Cantidad de agua utilizada? (L)				
2.2 ¿Cantidad de cal utilizada? (g)				
2.3 ¿Tiempo de cocción? (hr)				
2.4 ¿Número de lavados?				
2.5 ¿Cómo fue el desprendimiento de pericarpio?				
2.6 ¿Tiempo de reposo? (hr)				
2.7 ¿Satisfacción del nixtamal?				
2.8 Comentarios				

2.5_ 1: muy fácil, 2:fácil, 3:difícil,4:muy difícil
2.7_ 1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

3 Calidad de la masa

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Sinaloa	4 (204) H-565
3.1 ¿Tipo de molienda?				
3.2 ¿Rendimiento? (kg)				
3.3 ¿Satisfacción del color de la masa?				
3.4 ¿Satisfacción del aroma de la masa?				
3.5 ¿Satisfacción de la maleabilidad de la masa?				
3.6 Comentarios				

3.1_ 1: gruesa, 2: intermedia, 3:fina
3.3, 3.4 y 3.5_1: muy bueno, 2:bueno, 3:deficiente, 4:muy deficiente

4 Satisfacción de la variante de maíz en el producto final

4.3 TOTOPO	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Sinaloa	4 (204) H-565
4.3.1 ¿Cómo es el tiempo de cocción con este maíz?				
4.3.2 ¿Cómo es el grosor con este maíz?				
4.3.3 ¿Cómo es el dorado con este maíz?				
4.3.4 ¿Cómo es el aroma con este maíz?				
4.3.5 ¿Cómo es el color con este maíz?				
4.3.6 ¿Cómo es el rendimiento con este maíz?				
4.3.7 Comentarios				

1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

1.1 Comunidad: San Marcos Tlapazola 1.2 Fecha:_____

Nombre:_____ 1.3 Edad:_____1.4 Producto Tejate

2 Nixtamalización

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Sinaloa	4 (204) H-377
2.3 ¿Tiempo de cocción? (hr)				
2.4 ¿Número de lavados?				
2.5 ¿Cómo fue el desprendimiento de pericarpio?				
2.6 ¿Tiempo de reposo? (hr)				
2.7 ¿Satisfacción del cuanextle?				
2.8 Comentarios				

2.5_ 1: muy fácil, 2: fácil, 3: difícil, 4: muy difícil
2.7_ 1: muy bueno, 2: bueno, 3: deficiente, 4: muy deficiente

3 Calidad de la masa

Preguntas	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Sinaloa	4 (204) H-377
3.1 ¿Tipo de molienda?				
3.2 ¿Rendimiento? (kg)				
3.3 ¿Satisfacción del color de la masa?				
3.4 ¿Satisfacción del aroma de la masa?				
3.5 ¿Satisfacción de la suavidad de la masa?				
3.6 Comentarios				

3.1_ 1: gruesa, 2: intermedia, 3: fina
3.3, 3.4 y 3.5_1: muy bueno, 2: bueno, 3:deficiente, 4:muy deficiente

4 Satisfacción de la variante de maíz en el producto final

4.1 TEJATE	1 (201) Bolita	2 (202) Zapalote Chico	3 (203) Sinaloa	4 (204) H-377
4.1.1 ¿Cómo es el espesor con este maíz?				
4.1.2 ¿Cómo es la flor (espuma) con este maíz?				
4.1.3 ¿Cómo es el color con este maíz?				
4.1.5 Comentarios				

1: muy bueno, 2:bueno, 3:deficiente,4:muy deficiente

Anexo 6 Pruebas discriminativas

Prueba triangular

Nombre:			Fecha:
Sexo:	Edad:	Comunidad:	
Producto:			Prueba: 1

Instrucciones

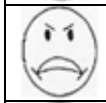
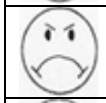
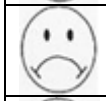
Pruebe las muestras de izquierda a derecha. Dos muestras son idénticas; determine con una "**X**" sobre el cuadro cuál es la muestra diferente.

Si no percibe una diferencia aparente, por favor, adivine

Muestras en charola	¿Cuál es la muestra diferente?	Comentarios
968	☐	_____
972	☐	
249	☐	_____
		_____

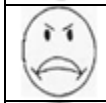
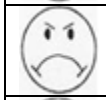
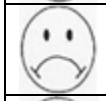
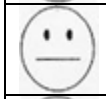
ANEXO 7 **PRUEBA DE ACEPTABILIDAD**

	Fecha:	Producto:	Prueba: 1
Nombre:	Edad:	Sexo:	
Instrucciones: Pruebe las muestras e indique el grado de aceptabilidad para cada uno de los atributos. Marque una **X** en el cuadro de la categoría que mejor represente su juicio.			

Categorías	968				972			
	Color	Aroma	Sabor	Textura	Color	Aroma	Sabor	Textura
 Me disgusta extremadamente								
 Me disgusta mucho								
 Me disgusta moderadamente								
 Me disgusta poco								
 Ni me disgusta ni me gusta								
 Me gusta poco								
 Me gusta moderadamente								
 Me gusta mucho								
 Me gusta extremadamente								

PRUEBA DE ACEPTABILIDAD

Comunidad:	Fecha:	Producto:	Prueba: 1
Instrucciones: Pruebe las muestras e indique el grado de aceptabilidad para cada uno de los atributos. Marque una **X** en el cuadro de la categoría que mejor represente su juicio.			

Categorías	249				11			
	Color	Aroma	Sabor	Textura	Color	Aroma	Sabor	Textura
 Me disgusta extremadamente								
 Me disgusta mucho								
 Me disgusta moderadamente								
 Me disgusta poco								
 Ni me disgusta ni me gusta								
 Me gusta poco								
 Me gusta moderadamente								
 Me gusta mucho								
 Me gusta extremadamente								

Anexo 8. Comparaciones múltiples de los maíces por producto.

Cuadro 1. Comparaciones múltiples de los diferentes maíces en tortilla por indicadores de calidad.

TORTILLA									
Maíz de referencia	**Maíz comparado**	**Color**		**Sabor**		**Aroma**		**Suavidad**	
		DM	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**
Cónico	Zapalote Chico	0.33	0.628	0.37	0.58	0.20	0.87	0.51	0.25
	Sinaloa	0.47	0.322	0.59	0.17	0.75*	0.03	0.87*	0.01
	Híbrido 377	1.01	0.002	0.76*	0.04	0.87*	0.01	0.99*	0.00
Zapalote Chico	Cónico	-0.33	0.628	-0.37	0.58	-0.20	0.87	-0.51	0.25
	Sinaloa	0.14	0.957	0.23	0.86	0.54	0.17	0.37	0.53
	Híbrido 377	0.68	0.064	0.39	0.52	0.67	0.06	0.48	0.29
Sinaloa	Cónico	-0.47	0.322	-0.59	0.17	-0.75*	0.03	-0.87*	0.01
	Zapalote Chico	.0.14	0.957	-0.23	0.86	-0.54	0.17	-0.37	0.53
	Híbrido 377	0.54	0.197	0.16	0.94	0.13	0.96	0.11	0.29
Híbrido 377	Cónico	-1.01	0.002	-0.76*	0.04	-0.87*	0.01	-0.99*	0.01
	Zapalote Chico	-0.68	0.064	-0.39	0.52	-0.67	0.06	-0.48	0.53
	Sinaloa	-0.54	0.197	-0.16	0.94	-0.13	0.96	-0.11	0.98

Tukey – Duncan (α= 0.05).Los datos marcados son significativamente diferentes.
*Valores significativos

Cuadro 2. Comparaciones múltiples de los diferentes maíces en nicuatole por indicadores de calidad.

NICUATOLE									
Maíz de referencia	**Maíz comparado**	**Color**		**Sabor**		**Aroma**		**Cuajado**	
		DM	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**
Bolita	Zapalote Chico	-0.03	1.000	-0.10	0.98	-0.17	0.94	-0.17	0.95
	Sinaloa	0.25	0.811	0.51	0.23	0.71	0.09	0.19	0.94
	Híbrido 377	0.33	0.656	0.83	0.01	0.40	0.55	0.33	0.74
Zapalote Chico	Bolita	0.03	1.000	0.10	0.98	0.17	0.94	0.17	0.95
	Sinaloa	0.28	0.762	0.61	0.11	0.89*	0.02	0.36	0.67
	Híbrido 377	0.35	0.599	0.93	0.00	0.57	0.23	0.50	0.40
Sinaloa	Bolita	-0.25	0.811	-0.51	0.23	-0.71	0.09	-0.19	0.94
	Zapalote Chico	-0.28	0.762	-0.61	0.11	-0.89*	0.02	-0.36	0.67
	Híbrido 377	0.08	0.993	0.31	0.65	-0.31	0.73	0.14	0.97
Híbrido 377	Bolita	-0.33	0.656	-0.83	0.01	-0.40	0.55	-0.33	0.74
	Zapalote Chico	-0.35	0.599	-0.93	0.00	-0.57	0.23	-0.50	0.40
	Sinaloa	-0.08	0.993	-0.31	0.65	0.31	0.73	-0.14	0.97

Tukey – Duncan (α= 0.05).Los datos marcados son significativamente diferentes.
*Valores significativos

.

Cuadro 3. Comparaciones múltiples de los diferentes maíces en tlayuda por indicadores de calidad.

TLAYUDA									
Maíz de referencia	**Maíz comparado**	**Color**		**Sabor**		**Aroma**		**Cocido**	
		DM	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**
Bolita	Zapalote Chico	0.08	0.995	-0.23	0.89	-0.36	0.67	-0.16	0.96
	Sinaloa	-0.03	1.000	-0.05	1.00	-0.50	0.40	0.21	0.92
	Híbrido 377	0.55	0.303	0.04	1.00	0.14	0.97	0.03	1.00
Zapalote Chico	Bolita	-0.08	0.995	0.23	0.89	0.36	0.67	0.16	0.96
	Sinaloa	-0.1	0.989	0.18	0.94	-0.14	0.97	0.37	0.68
	Híbrido 377	0.48	0.435	0.26	0.84	0.50	0.40	0.19	0.95
Sinaloa	Bolita	0.03	1.000	0.05	1.00	0.50	0.40	-0.21	0.92
	Zapalote Chico	0.1	0.989	-0.18	0.94	0.14	0.97	-0.37	0.68
	Híbrido 377	0.58	0.265	0.09	0.99	0.64	0.19	-0.19	0.95
Híbrido 377	Bolita	-0.55	0.303	-0.04	1.00	-0.14	0.97	-0.03	1.00
	Zapalote Chico	-0.48	0.435	-0.26	0.84	-0.50	0.40	-0.19	0.95
	Sinaloa	-0.58	0.265	-0.09	0.99	-0.64	0.19	0.19	0.95

Tukey – Duncan (α= 0.05).Los datos marcados son significativamente diferentes.
*Valores significativos

Cuadro 4. Comparaciones múltiples de los diferentes maíces en tejate por indicadores de calidad.

TEJATE									
Maíz de referencia	**Maíz comparado**	**Color**		**Sabor**		**Aroma**		**Espeso**	
		DM	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**
Bolita	Zapalote Chico	0.99*	0.00	0.05	1.00	0.49	0.46	0.21	0.94
	Sinaloa	0.48	0.37	0.11	0.99	0.21	0.92	-0.19	0.96
	Híbrido 377	0.98*	0.08	0.30	0.83	0.64	0.23	-0.02	1.00
Zapalote Chico	Bolita	-0.99*	0.00	-0.05	1.00	-0.49	0.46	-0.21	0.94
	Sinaloa	-0.51	0.20	0.06	1.00	-0.27	0.84	-0.40	0.70
	Híbrido 377	-0.01	0.62	0.25	0.90	0.15	0.97	-0.24	0.92
Sinaloa	Bolita	-0.48	0.37	-0.11	0.99	-0.21	0.92	0.19	0.96
	Zapalote Chico	0.51	0.20	-0.06	1.00	0.27	0.84	0.40	0.70
	Híbrido 377	0.50	0.87	0.19	0.95	0.42	0.58	0.16	0.97
Híbrido 377	Bolita	-0.98*	0.08	-0.30	0.83	-0.64	0.23	0.02	1.00
	Zapalote Chico	0.01	0.62	-0.25	0.90	-0.15	0.97	0.24	0.92
	Sinaloa	-0.50	0.87	-0.19	0.95	-0.42	0.58	-0.16	0.97

Tukey – Duncan (α= 0.05).Los datos marcados son significativamente diferentes.
*Valores significativos

Cuadro 5. Comparaciones múltiples de los diferentes maíces en totopo por indicadores de calidad.

TOTOPO									
Maíz de referencia	**Maíz comparado**	**Color**		**Sabor**		**Aroma**		**Crujencia**	
		DM	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**
Bolita	Zapalote Chico	1.23*	0.03	0.74	0.16	0.89*	0.03	0.81	0.11
	Sinaloa	0.55	0.53	0.50	0.49	0.44	0.53	0.68	0.23
	Híbrido 565	0.81	0.03	0.08	1.00	0.30	0.79	0.08	1.00
Zapalote Chico	Bolita	-1.23*	0.03	-0.74	0.16	-0.89*	0.03	-0.81	0.11
	Sinaloa	-0.68	0.47	-0.24	0.91	-0.45	0.51	-0.14	0.98
	Híbrido 565	-0.41	1.00	-0.66	0.24	-0.59	0.27	-0.74	0.17
Sinaloa	Bolita	-0.55	0.53	-0.50	0.49	-0.44	0.53	-0.68	0.23
	Zapalote Chico	0.68	0.47	0.24	0.91	0.45	0.51	0.14	0.98
	Híbrido 565	0.26	0.49	-0.42	0.62	-0.14	0.97	-0.60	0.34
Híbrido 565	Bolita	-0.81	0.03	-0.08	1.00	-0.30	0.79	-0.08	1.00
	Zapalote Chico	0.41	1.00	0.66	0.24	0.59	0.27	0.74	0.17
	Sinaloa	-0.26	0.49	0.42	0.62	0.14	0.97	0.60	0.34

Tukey – Duncan (α= 0.05).Los datos marcados son significativamente diferentes.
*Valores significativos

Cuadro 6. Comparaciones múltiples de los diferentes maíces en totopo ECOSUR por indicadores de calidad.

TOTOPO ECOSUR									
Maíz de referencia	**Maíz comparado**	**Color**		**Sabor**		**Aroma**		**Crujencia**	
		DM	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**	**DM**	**Sig.**
Bolita	Zapalote Chico	-0.30	0.59	-0.73*	0.03	-0.10	0.98	-0.61	0.14
	Sinaloa	-0.71	0.02	-0.65	0.06	-0.30	0.60	-0.53	0.25
	Híbrido 565	-1.15	0.00	-0.84*	0.01	-0.40	0.34	-0.96	0.00
Zapalote Chico	Bolita	0.30	0.59	0.73*	0.03	0.10	0.98	0.61	0.14
	Sinaloa	-0.41	0.31	0.08	0.99	-0.20	0.84	0.09	0.99
	Híbrido 565	-0.85	0.00	-0.11	0.97	-0.30	0.60	-0.35	0.60
Sinaloa	Bolita	0.71	0.02	0.65	0.06	0.30	0.60	0.53	0.25
	Zapalote Chico	0.41	0.31	-0.08	0.99	0.20	0.84	-0.09	0.99
	Híbrido 565	-0.44	0.26	-0.19	0.89	-0.10	0.98	-0.44	0.41
Híbrido 565	Bolita	1.15	0.00	0.84*	0.01	0.40	0.34	0.96	0.00
	Zapalote Chico	0.85	0.00	0.11	0.97	0.30	0.60	0.35	0.60
	Sinaloa	0.44	0.26	0.19	0.89	0.10	0.98	0.44	0.41

Tukey – Duncan (α= 0.05).Los datos marcados son significativamente diferentes.
*Valores significativos

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Maize races on functional and nutritional quality of *tejate*: A maize-cacao beverage

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ABSTRACT

Tejate is a Mesoamerican beverage made mainly with maize-cacao. Despite the economic importance of *tejate* in Oaxaca and Southwest US, the characteristics that maize should have for good quality *tejate* are not well known. The aim was to evaluate the native races of maize commonly used in *tejate* preparation. *Tejate* showed excellent source of minerals (Ca, Fe, Zn, K, Mg, P), where white Bolita maize showed higher levels. Starch annealing during nixtamalization with wood ashes showed that white Bolita produced a *tejate* with higher resistant starch type 5 (RS5) and the greatest consistency (1146 cP) compared with the other maize landraces. X-ray diffraction patterns showed a peak at 4.45 Å of amylose-lipid complex. The white Bolita maize had the highest RS5 in tejate (2.68 g/100 g) and low glycemic index (GI 38.21), compared with other *tejate* samples that ranged from 1.04 to 2.07 g/100 g of RS5, and GI of 23.09–74.46. *Tejate* consumption maintains blood with normal glucose responses.

1. Introduction

Mexico is the center of origin of maize (*Zea mays* L.), this staple crop that forms the primary basis of much of indigenous culture. For centuries, people in Mexico and South America developed new maize varieties adapting them not only to local conditions but also to their special cultural and culinary needs (Figueroa, Véles, & Hernández et al., 2013). Several maize products at industrial and domestic levels are elaborated using the nixtamalization process, such as *tejate*, tortillas, tamales, pozole among many others maize food products. *Tejate* is a distinct maize product because the maize is nixtamalized with ashes, instead of lime (calcium hydroxide [$Ca(OH)_2$]) as is the case for most maize foods. Nixtamalization with ashes known as the Classic Process, was developed by the Mayans in the pre-Classic period of 1200-250 BC. Later the Aztecs substituted ashes with lime in the Traditional Nixtamalization that we use today in commercial operations. Classic Nixtamalization with ashes appears to have different outcomes in terms of dietary fiber and resistant starch and mineral content. Additionally, the cacao is the other ingredient of *tejate* that has antioxidant, cardiovascular protector and antitumoral properties (Rusconi & Conti, 2010). Human clinical studies with chocolate were performed by Kondo, Hirano, Matsumoto, Igarashi, and Itakura (1996) who found that 35 g of cocoa (cacao) decreased low-density lipoproteins (LDL) oxidation between 2 and 4 h after ingestion. A relatively modest 6 g portion of dark chocolate, gave 30 kcal, similar to the amount used in *tejate*, produces measurable reductions in blood pressure (Taubert, Roesen, Lehmann, Jung, & Schömig, 2007). In addition, there is significant evidence those polyphenol antioxidants in chocolate and cacao act as systemic inflammatory mediators, reducing platelet and endothelial cell activation and the expression of inflammatory mediators (McShea, Leissle, & Smith, 2009).

The original chocolate or *cacao for drinking* was a beverage made of water, ground cacao and ash-nixtamalized maize (Garibay, 2013). In tejate the proportion of cacao is relatively low, only 6 g/100 g, in order to obtain several synergistic nutraceutical properties of maize

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and cacao components from the chemical complexes formed during preparation. Regarding the dietary contributions of *tejate*, these will depend more on the rest of the diet, either based on its preparation or on other ingredients in this traditional beverage.

The present study investigated *Tejate*'s chemical and nutritional characteristics, using samples including *tejate* prepared for home consumption and market sale, and using different native races of maize as well as the traditional recipe. We quantified the proximate composition (ashes, fat, protein, crude fiber, carbohydrates), mineral contribution (Ca, Fe, Zn, K, Mg and P), the presence of type 5 resistant starch (RS5), enzymatic RS5, and the *in vitro* glycemic index of *tejate*, aiming to establish the different implications for public health.

2. Materials and methods

2.1. Materials

White Bolita, yellow Bolita and Chalqueño maize races were recollected in San Andrés Huayapam, Oaxaca. Cacahuacintle a soft kernel maize obtained in the commercial market in Querétaro, Mexico, was used as a control. Samples were stored in a cool room at 4 °C.

Two commercial *tejate* samples were included. The "tejatli" sample from Zimatlán and the "Tejayapam" sample from San Andrés Huayapam, Oaxaca. In addition for the ash nixtamalize maize (Classic Nixtamalization Process) wood ashes of oak tree (*Quercus ssp.*) obtained from the women that make *tejate* at San Andrés Huayapam, Oaxaca were used.

2.2. Physical features

The weight of 1000 kernels was determined for each sample (Narváez-González, Figueroa-Cárdenas, Taba, & Rincón, 2006). Flotation index was determined by placing 100 kernels in a beaker containing 300 mL of $NaNO_3$ solution (1.250 g/mL). They were stirred to separate the kernels and left standing for 1 min. The number of floating kernels indicated the flotation index (Narváez-González et al., 2006). The test was performed in duplicate. Test weight (TW) was the weight of grain required to fill a level of 35.24 dm^3 capacity reported in kg/hL (AACCI 2000).

2.3. Chemical composition

Moisture was analyzed according to the AACC International (2000) method AACC 44-19.01; ash according to method AACC 08-03.01; fat according to method AACC 30-25.01; protein according to method AACC 46-13.01; and crude fiber according to method AACC 32-10.01; total starch AACC method 76.13; resistant starch AACC method 32-40.01. Carbohydrate content was calculated on dry weight basis as followed: 100-(protein content + ashes + fat + fiber). Metabolizable energy using the Atwater conversion factors for cornmeal whole ground: protein 11.4 kJ/g (2.73 kcal/g), fat 35 kJ/g (8.37 kcal/g), carbohydrate 16.9 kJ/g (4.03 kcal/g) (FAO, 2003). The conversion factors for Joules and calories are: 1 kJ = 0.239 kcal; and 1 kcal = 4.184 kJ.

2.4. X-ray diffraction

The use of solvents and drying conditions during the isolation and purification of starch causes some changes in the X-ray diffraction patterns (Shogren, Fanta, & Felker, 2006). To avoid these problems, starches in maize, *cuanextle* and *tejate* were characterized using X-ray diffraction, Rapid Visco-Analyzer (RVA) and Differential Scanning Calorimeter (DSC) without extracting the starch.

All samples with moisture content of 7 g/100 g were placed on a glass surface and scanned from 5 to 50° on the 2θ scale using a Rigaku X-ray diffractometer DMAX-2100, which operates at 30 kV and 16 mA with a CuKα radiation of λ = 1.5405. The interplanar spacings (*d*) of the peaks were calculated using the Bragg equation $n\lambda = 2d \sin\theta$ (Figueroa, Véles-Medina, & Tolentino-López et al., 2013).

2.5. Pasting properties

A Rapid Visco-Analyzer (RVA) (3C Model Newport Scientific PTY LTD, Sydney, Australia) was used to determine the viscoamylographic curve. The Rapid Visco-Analyzer (RVA) is a rotational viscometer that continuously records the viscosity of a sample under conditions of controlled temperature and shear. The method used was that reported by Narváez-González et al. (2006).

2.6. Thermal properties

A calorimeter (821 Model DSC Mettler Toledo) equipped with a thermal analysis data station was used. The DSC measures temperatures and heat flows associated with thermal transitions in a material. Gelatinization onset (To), peak (Tp), and final (Tf) temperatures, as well as enthalpy (ΔH), were obtained directly from the analysis of the software Mettler Toledo® for windows. The method was reported by Narváez-González et al. (2006). Each sample was run in duplicate.

2.7. Percentage of gelatinization

With use of the gelatinization enthalpy of raw maize (ΔHn), the percentage of gelatinization of the cuanextle, and tejate (ΔHs) was determined according to method proposed by (Baks et al., 2007).

$$Gelatinization = \left(1 - \frac{\Delta Hs}{\Delta Hn}\right) * 100$$

2.8. Classic nixtamalization process (using ashes) for tejate

Maize grain was processed by the classic nixtamalization (*Cuanextle*): 100 g were cooked with 2 L of water and 75 g/100 g (w/w) of wood ashes at 90 °C for about 30–45 min and the cooked grains were steeped from 65 °C to room temperature for 16 h. The nixtamal from the classic process was rinsed (Fig. 1). The nixtamal kernel was milled into a stone mill (*metate*) with a coarse particle size to get the masa for *tejates*. The masa was dehydrated using a stove at 40 °C and store for analysis.

2.9. Tejate preparation

Tejate is a Mesoamerican foam-topped beverages made with maize (*Z. mays* L.), cacao seeds (*Theobroma cacao* L.), and other ingredients as blossoms known as "*rosita de cacao*" (*Quararibea funebris*) 20 g, which aroma resembles essential oils of hops and pixtle (10 mamey seeds of *Pouteria sapota*). The preparation is by grinding in *metate* (mortar) and *metatlpilli* or *mano* (pestle) 180 g of toasted cacao beans alone, then grinding them together with 3 kg of ash nixtamalized maize, after that the two masas (cuanextle-masa and cacao-masa) are combined and ground together with the other toasted ingredients (Fig. 1), after which 10 L of water stream was poured in order to create a foam-topped beverage.

2.10. Glycemic index in vitro

Tejate glycemic index was determined *in vitro* according to Novotni et al. (2012). Four different *tejate* beverages were tested

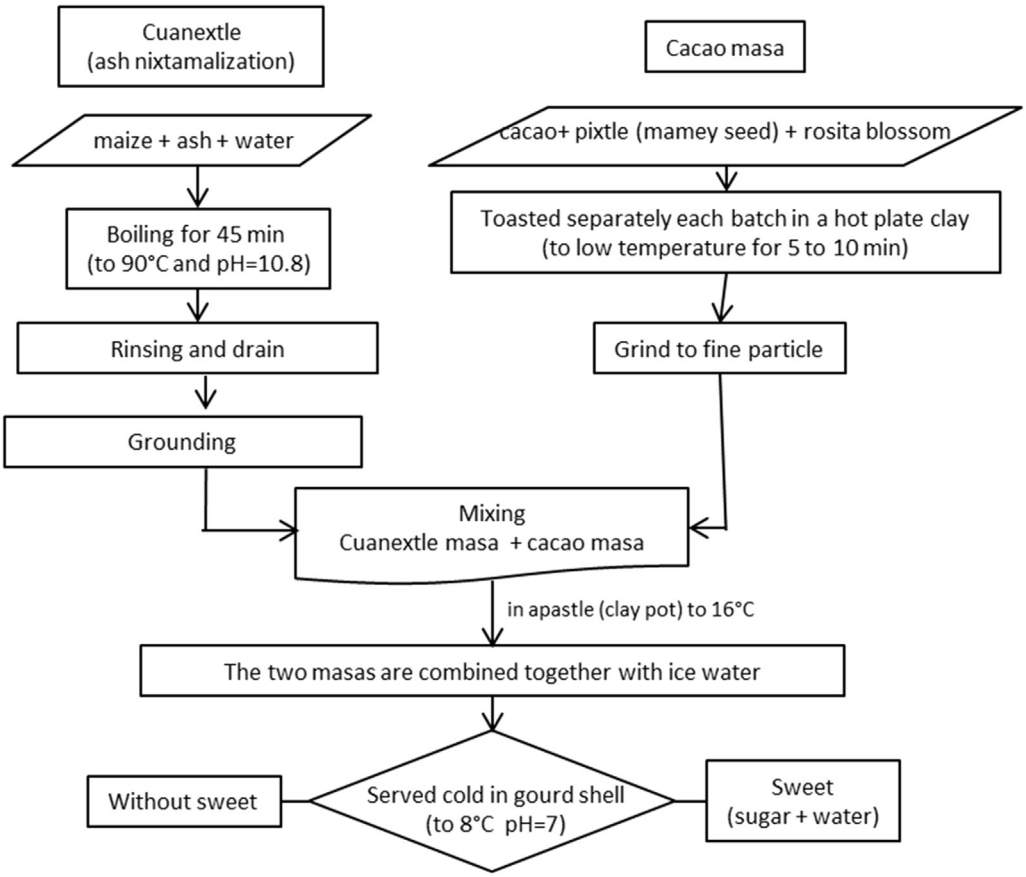

Fig. 1. Traditional tejate preparation, including ash nixtamalization (cuanextle-masa) and cacao-masa steps.

once by each of four volunteers. Glucose solution, which was used as the reference, was prepared by dissolving 50 g of pure anhydrous glucose in 250 mL of water. Portions of *tejate* containing 50 g of available carbohydrates were consumed by each volunteer over 10 min time period, with 250 mL of water. *Tejates* were consumed in random order on separate occasions in the morning after a 12 h overnight fast. Capillary finger-prick blood samples were taken from subjects at 0, 15, 30, 45, 60, 90, and 120 min after in accordance to sample intake (time 0). Blood glucose concentrations were measured using One Touch Ultra-Mini automatic blood glucose meter. The One touch Ultra Mini kit (specially indicated for finger) was approved as *in vitro* test in 2006 by the FDA Department of Health and Human Services. The glucose meter was checked for accuracy using high, low and normal test solution available from the manufacturer. The area under the blood glucose response curve for each *tejate* expressed as a percentage of the area after taking the same amount of carbohydrate as glucose.

2.11. Minerals

The quantification of minerals was performed using the ICP-OES (inductively coupled plasma optical emission spectrometry) following the method 40-75.01 of AACC International (2000).

2.12. Statistical analysis

The means comparison in the analysis of variance was carried out using Duncan's test with a Statistical Analysis System (SAS Institute, 2009).

3. Results and discussion

Table 1 shows the physicochemical properties of maize used in the ash nixtamalization process for the elaboration of *tejate*. The Oaxacan people claim that Bolita white maize landrace (maize race) is best for use in preparing tejate, and to give a quality that is not obtained with other maize landraces. Several samples were collected from the local communities of Oaxaca and others were maize control with different endosperm types (Table 1). Table 1 shows that white Bolita has a relatively soft kernel as indicated by the flotation index (FI = 30) compared to yellow Bolita and Chalqueño. The whitest color (L = 71.78) and softest maize kernel was Cacahuacintle.

3.1. Proximate composition

The high levels of chemical components in *tejate* compared to the counterpart maize landraces are due to the other ingredients such as pixtle, cuanextle (ash masa) and r*osita de cacao* (Table 2). *Tejate* showed about 2 g/100 g higher protein, 1 g/100 g higher ash and 7 g/100 g higher lipids than the counterpart maize samples. Some authors have indicated that *pixtle* and *rosita de cacao* are ingredients used exclusively in the preparation of *tejate* (Sotelo, Soleri, Wacher, Sánchez-Chinchillas, & Argote, 2012). *Tejate* is one component of the maize-centered dietary traditions of the Central Valleys of Oaxaca, Mexico. This beverage likely played a special role in local diets either replacing or complementing the nutritional contributions of other maize foods and their accompaniments. Indeed, in the quantities typically consumed, the protein and energy contributions of *tejate* can be comparable to that of maize

Table 1
Physicochemical properties of maize samples.[a]

Race	Length (mm)	Wide (mm)	Thickness (mm)	Moisture (mg/100 g)	TKW (g)	TW (kg/hL)	FI	Color L	Color tejate L
White Bolita	11.78 ± 0.81c	11.25 ± 1.02b	4.49 ± 0.57b	10.5 ± 0.12c	441.63 ± 7.70a	79.05 ± 0.76b	30 ± 6.02b	62.12 ± 1.44b	33.83 ± 0.34c
Yellow Bolita	12.05 ± 0.41c	11.21 ± 0.53b	4.36 ± 0.53b	10.3 ± 0.08c	440.13 ± 18.99a	80.75 ± 0.65a	10 ± 2.52c	51.03 ± 1.31c	39.44 ± 0.11a
Chalqueño	12.95 ± 0.96b	9.19 ± 0.68c	4.54 ± 0.64b	12.7 ± 0.18a	387.68 ± 3.11b	74.37 ± 0.48c	19 ± 1.00c	63.63 ± 0.31b	33.31 ± 0.01d
Cacahuacintle	15.11 ± 0.80a	13.48 ± 0.71a	6.45 ± 0.83a	11.3 ± 0.01b	391.42 ± 7.76b	65.00 ± 0.30d	66 ± 2.00a	71.78 ± 1.26a	35.34 ± 0.10b

TKW = Thousand kernel weight; TW = Test weight; FI = Flotation index.
[a] Means ± SD followed by the same letter in the same column are not significant different at $P < 0.05$.

Table 2
Proximate chemical composition of maize and tejate samples.[a]

Race	Protein (g/100 g)	Ash (g/100 g)	Lipids (g/100 g)	Crude fiber (g/100 g)	CHO (g/100 g)	Energy kcal/100 g	Energy kJ/100 g
Maize							
White Bolita	6.42 ± 0.01c	1.30 ± 0.15a	6.78 ± 0.02a	0.49 ± 0.01d	85.03 ± 0.18bc	416.9 ± 0.5a	1747.2 ± 2.1a
Yellow Bolita	6.72 ± 0.09b	1.70 ± 0.43a	6.45 ± 0.09a	1.19 ± 0.07a	84.25 ± 0.31c	411.8 ± 2.3b	1725.9 ± 9.5b
Chalqueño	6.91 ± 0.00a	1.59 ± 0.28a	4.82 ± 0.35b	0.64 ± 0.07c	86.05 ± 0.56b	406.7 ± 0.7c	1704.7 ± 2.7c
Cacahuacintle	5.96 ± 0.07d	1.25 ± 0.21a	4.60 ± 0.22b	0.87 ± 0.02b	87.33 ± 0.49a	406.7 ± 0.1b	1701.5 ± 0.5c
Tejate (not sugar added)							
White Bolita	7.25 ± 0.63c	2.30 ± 0.01a	11.47 ± 0.23b	0.79 ± 0.14c	78.20 ± 0.28b	430.0 ± 0.9b	1805.6 ± 3.9b
Yellow Bolita	8.86 ± 0.03a	1.70 ± 0.43b	12.11 ± 0.07a	1.04 ± 0.08b	76.30 ± 0.30d	433.0 ± 1.7a	1814.2 ± 7.3a
Chalqueño	8.11 ± 0.22b	2.14 ± 0.06 ab	11.60 ± 0.02b	0.99 ± 0.14b	77.18 ± 0.29c	430.2 ± 0.4b	1802.5 ± 1.7b
Cacahuacintle	8.34 ± 0.15a	2.59 ± 0.15a	11.99 ± 0.23a	1.24 ± 0.05a	76.30 ± 0.02d	428.8 ± 1.6b	1796.6 ± 6.6b
Tejayapam	8.87 ± 0.22a	0.60 ± 0.14c	8.52 ± 0.04c	1.24 ± 0.07a	80.78 ± 0.18a	421.0 ± 0.2c	1764.3 ± 0.6c

†Data reported in dry basis. CHO = Carbohydrates.
[a] Means ± SD followed by the same letter in the same column are not significant different at $P < 0.05$.

tortillas (Sotelo et al. 2012). Regarding energy, most of the caloric content comes from maize, and since the formulation of *tejate* has only 6 g/100 g of cacao this gives about 20 kcal/100 g mainly from lipids (Table 2). The present data agrees with the reported data of *tejate* except that the relatively higher values found may be due to the sugar added to sample and the different factors used (Sotelo et al. 2012). Part of the lipids and carbohydrates from maize and cacao are in the form of amylose-lipid complexes that are resistant to enzymatic attack and relatively high temperatures (90°–130 °C). Figueroa, Véles, & Hernández et al. (2013) reported that a practical way to introduce the amylose-lipid complexes by the use of selected heat/moisture treatments was patented by several authors (Dudasek, Kochan, & Zobel, 1985; Wursch & Roulet, 1992; Yuan & Rudie, 2001). They indicated that the naturally occurring fatty acids and phospholipids can complex with the amylose fraction at high temperatures. Selected treatments might include combinations of high moisture levels >18–45 g/100 g w/w, temperatures of 90–130 °C, and holding time of 1–16 h (Zobel, 1988) similar to those used by the Mayans several centuries ago in the ash nixtamalization and cacao oils for the preparation of *tejate*.

3.2. Minerals

Tejate is an important source of Ca, Mg, Fe, Zn and P that met the daily intake recommended values (WHO/FAO 1998), all of which are important micronutrients (Table 3). *Tejate* samples prepared with soft endosperm Cacahuacintle and white Bolita maize landrace showed significant higher levels of minerals compared to Chalqueño and yellow Bolita landrace that presented hard endosperm according to the flotation index (Table 1). The white Bolita maize is commonly used for making good quality *tejate* in Oaxaca due to its special taste (data not shown) attributed to minerals provided by the ash nixtamalization process (Classic Process) and also by the cacao amylose-lipid complexes. The yellow Bolita and Chalqueño maize are also used when white Bolita maize is not available. However, yellow Bolita showed lower mineral composition compared to the other samples (Table 3). Although, there are very high levels of minerals in the wood ashes, only about 0.2 g/100 g of these minerals were incorporated in the final product. Maize, like other cereal grains, is very low in minerals. Most of the minerals in maize are lost during washing and rinsing processing steps. The wood ashes contributed almost twice the amount of minerals in the final *tejate* (Table 3). Commercial *tejate* (Tejayapam) showed twice the level of Ca and half of the Fe content, which suggests that commercial *tejate* uses food grade lime [$Ca(OH)_2$] instead of the traditional wood ash during nixtamalization. Since wood ashes are a good source of Fe and low grade lime usually has Fe, these raw materials are an inexpensive source of Fe which helps prevention of anemia.

An important contribution from the nixtamalization process is the considerable increase in mineral content especially Ca and Fe, in maize products such as *tejate* and tortillas as compared with that of raw corn (Table 3). Figueroa, Acero, and Quezada (2008) reported that tortillas provided 368 mg of the daily requirement of Ca, where the tortilla consumption is about 325 g/day. Other authors have reported that *tejate*, in the quantities typically consumed in Oaxaca (2 servings of 237 mL each), the protein, minerals and energy contributions of *tejate* can be comparable to that of tortillas nixtamalized with lime (Sotelo et al., 2012). Indeed, a study comparing the properties of maize treated with lime vs. wood ash found that ash-nixtamalized maize contains 14.4 times the level of Fe, 15.0 times the level of Zn, twice as much Mg and 8.4 times K (Pappa, Palacios, & Bressani, 2010). Thus, as result of its ash nixtamalization, *tejate* can be a relatively mineral-rich maize food.

3.3. Thermal properties of annealed starch in cuanextle and tejate

The DSC thermal properties of starch in *cuanextle* and *tejate* show higher onset, peak and final gelatinization temperatures and a narrower the gelatinization range than the starch in maize counterparts (Table 4). These conditions are typical of annealed starches (Figueroa, Véles, & Hernández et al., 2013; Figueroa, Véles-Medina, & Tolentino-López et al., 2013; Jacobs & Delcour, 1998; Qi et al., 2004). The DSC thermal properties of processed white Bolita

Table 3
Mineral composition of tejate.[a]

Tejate samples	Calcium mg/100 g	Iron mg/100 g	Zinc mg/100 g	Potassium mg/100 g	Magnesium mg/100 g	Phosphorus mg/100 g
White Bolita	54.67 ± 1.55a	5.33 ± 0.06b	1.50 ± 0.00b	66.60 ± 0.85b	112.60 ± 0.80b	177.23 ± 2.91b
Yellow Bolita	34.67 ± 1.14c	0.40 ± 0.00c	1.33 ± 0.06d	28.57 ± 0.15d	78.53 ± 0.40c	122.07 ± 5.52c
Chalqueño	46.90 ± 1.35b	5.26 ± 0.06b	1.40 ± 0.00c	62.70 ± 0.00c	112.33 ± 0.78b	179.43 ± 1.65b
Cacahuacintle	52.40 ± 1.08a	6.63 ± 0.06a	1.80 ± 0.00a	75.13 ± 0.40a	122.23 ± 2.00a	205.90 ± 11.66a
Tejayapam (commercial)	122.33 ± 0.72	2.87 ± 0.06	2.22 ± 0.00	66.20 ± 1.11	127.59 ± 0.63	188.35 ± 12.33
Wood ashes	21,929.03 ± 520.79	544.52 ± 8.54	56.232 ± 0.76	907.70 ± 17.87	2379.88 ± 16.69	1101.68 ± 22.87
Lime $Ca(OH)_2$	40,250	60.8	1.1	–	–	–
Lime food grade	52,200	9.0	1.1	–	–	–
Maize[b]	7.7	2.9	1.4	–	–	–
Tortilla[b]	114	1.2	1.8	–	–	–
Maize[c]	16.86	3.32	3.65	269.87	91.93	–
Tortilla[c]	177	1.4	1.4	192	65	–
Tejate[c]	26	4.56	1.9	186	66	–
Cuanextle[c]	72.99	8.83	9.58	423.78	212.95	–

[a] Means ± SD followed by the same letter in the same column are not significant different at $P < 0.05$.
[b] Figueroa et al. (2008).
[c] Sotelo et al.(2012).

race maize show annealing effects with the Classic ash nixtamalization as indicated by the increase in To, Tp and Tf (arrow 1), in *cuanextle* (ashed masa) and *tejate* with the ingredients compared to native maize without any processing (Fig. 2; Table 4). The increase of gelatinization temperature was about 10 °C from maize to *cuanextle* in white Bolita and a decrease of 5 °C in *tejate* made from the same maize (Table 4 and Fig. 2). Some authors have indicated that annealing results in a more perfectly-ordered structure, increased granule stability, and resistance to enzymatic attack and resistance to processing temperatures (Figueroa, Véles, & Hernández et al., 2013). Although all the maize landraces showed annealing, the white Bolita and Cacahuacintle showed the most notable effects due to softer kernels as indicated by FI. The viscosity of starch water suspensions evaluated by RVA in maize, *cuanextle* and *tejate* showed that white Bolita landrace presented higher peak viscosity in maize and maize products compared with the other maize landraces (Table 4). In addition to the annealing effect, the mixture of *cuanextle* with cacao masa at room temperature produced two endothermic forms labeled as (arrow 1), and (arrow 2) (Fig. 2). Peak (1) is due to starch gelatinization, however the starch in *tejate* from white Bolita showed the formation of starch-lipid complexes (arrow 2) as indicated by the inflexion about 40–60 °C in the DSC thermogram (Fig. 2). The starch-lipid complexes are also named V type starch or resistant starch (RS5), and have important health benefits for consumers. The dietary incorporation of V-complex to replace traditional carbohydrates may be beneficial for diabetic patients because of the decreased digestibility and subsequent glucose absorption rate (Murray et al. (1998). Therefore, resistant starch is emerging as an important dietary component that has the potential to reduce the incidence of bowel health disorders (Morrell, Konik-Rose, Ahmed, Li, & Rahman, 2004).

3.4. X-ray diffraction patterns starch type A and starch type V

Preliminary X-ray diffraction showed peaks at 5.8 Å and 3.8 Å of type A starch pattern described by Zobel (1988) decrease in starch from maize and *cuanextle* annealed starch. Additional processing of *cuanextle* with cacao masa to prepare *tejate* increased the peak at 4.45 Å, a characteristic of type V diffraction of amylose-lipid. This data agrees with Pérez and Bertoft (2010) and Tang & Copeland, (2007) who indicated that the starch-lipid complex in an amorphous state can be changed into a more ordered semi-crystalline V type diffraction (Fig. 3). The decrease in peaks at 5.8 and 3.8 Å of amylopectin in maize and *cuanextle* suggests that side branches of amylopectin form new amylose helices (Zobel, 1988) as indicated by the increase of amylose peak at 4.45 Å (Fig. 3). Similar products

Table 4
Effect of annealing on thermal properties of maize, cuanextle and tejate.[a]

Race	To (°C)	Tp (°C)	Tf (°C)	ΔH (J/g)	Gelatinization (%)	Pasting Temp (°C)	Peak viscosity (cP)	Set back (cP)	Viscosity maximum (cP)
Maize									
White Bolita	63.03 ± 0.10a	69.95 ± 0.00a	77.47 ± 0.13a	7.33 ± 0.13b	.	70.88 ± 0.25a	3246 ± 1c	1749 ± 100b	4989 ± 203b
Yellow Bolita	63.35 ± 0.12a	69.86 ± 0.12a	77.34 ± 0.28a	7.00 ± 0.03b	.	70.53 ± 0.81a	3009 ± 225c	1759 ± 4b	4747 ± 209b
Chalqueño	60.88 ± 0.26b	68.71 ± 0.11b	76.97 ± 0.55a	6.29 ± 0.01c	.	69.95 ± 0.00a	3753 ± 8b	1952 ± 1a	4938 ± 145b
Cacahuacintle	58.89 ± 0.57c	66.38 ± 0.12d	73.84 ± 0.13b	7.67 ± 0.17a	.	67.80 ± 0.00a	4380 ± 18a	1952 ± 98a	5690 ± 101a
Cuanextle									
White Bolita	69.25 ± 0.83a	76.69 ± 2.17a	85.89 ± 4.80a	4.93 ± 0.52a	32.64 ± 8.69a	73.26 ± 0.53a	2749 ± 167a	1275 ± 111 ab	4876 ± 337a
Yellow Bolita	64.99 ± 1.58b	73.28 ± 2.08a	83.24 ± 4.50a	3.66 ± 0.64 ab	47.77 ± 9.40a	69.05 ± 0.28c	1966 ± 110c	1434 ± 60a	4085 ± 235b
Chalqueño	64.41 ± 0.76a	78.27 ± 0.94a	90.36 ± 1.40a	3.38 ± 0.32b	46.34 ± 5.18a	70.48 ± 0.72b	2307 ± 18b	1277 ± 11 ab	4325 ± 76 ab
Cacahuacintle	68.35 ± 1.27 ab	75.04 ± 2.21a	83.92 ± 5.62a	4.50 ± 0.49 ab	41.30 ± 7.66a	72.15 ± 0.00a	2067 ± 55bc	1147 ± 18b	3728 ± 96b
Tejate									
White Bolita	67.96 ± 0.45a	74.13 ± 0.71a	80.87 ± 0.67a	3.98 ± 0.04a	45.70 ± 0.68c	72.35 ± 0.28a	1446 ± 29a	1151 ± 1a	2702 ± 72a
Yellow Bolita	65.44 ± 0.01bc	71.75 ± 0.11b	79.28 ± 0.01b	2.66 ± 0.02c	62.07 ± 0.45a	72.35 ± 0.28a	995 ± 11d	897 ± 0c	1845 ± 30d
Chalqueño	64.69 ± 0.62c	72.58 ± 0.12b	80.55 ± 0.22a	2.89 ± 0.33c	54.14 ± 0.52b	70.15 ± 0.21b	1109 ± 25b	1049 ± 28b	2128 ± 76bc
Cacahuacintle	65.99 ± 0.06b	72.30 ± 0.21b	78.99 ± 0.01b	3.45 ± 0.13b	55.09 ± 0.76 ab	71.80 ± 0.00a	1378 ± 20a	1122 ± 27a	2510 ± 7b
Tejayapam Control	66.53 ± 0.41	73.90 ± 0.14	81.10 ± 0.71	4.99 ± 0.08	33.09 ± 1.05	71.98 ± 0.25	2678 ± 458	1882 ± 264	4332 ± 541

[a] Means ± SD followed by the same letter in the column within the same group are not significant different at $P < 0.05$.

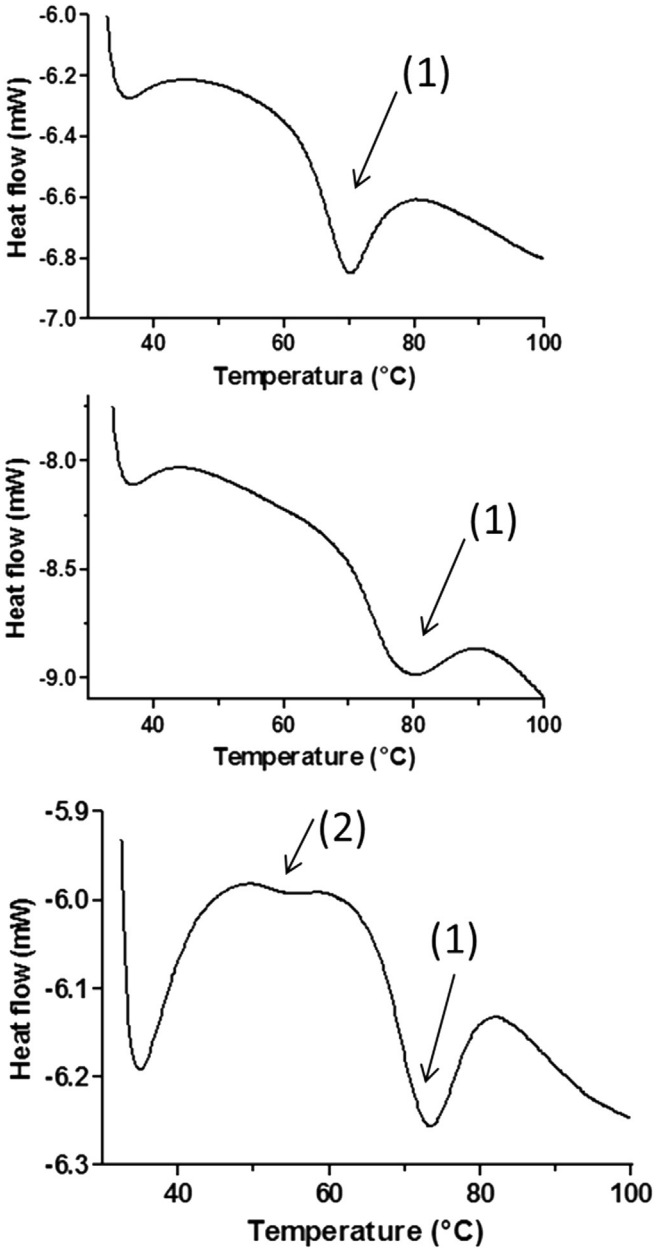

Fig. 2. Thermal properties of raw starch in maize, cuanextle (ash masa) and annealed starch in tejate using differential scanning calorimeter. (1) Starch gelatinization endothermic form; (2) Starch lipid complexes in tejate (40–60 °C).

containing gelatinized high-amylose starch and lipids were reported by several authors (Dudasek et al., 1985; Wursch & Roulet, 1992; Yuan & Rudie, 2001), which are believed to be in the form of complexes, as seen by X-ray diffraction and confirmed by differential scanning calorimetry (DSC) in the present study. The implications of these changes in the processing parameters and in the quality of final *tejate* merit additional investigations.

3.5. V type starch in tejate beverage

Tejate beverage presented important X-ray V Type crystalline starch structures with an interplanar distance of 4.45 Å (Fig. 3). It is widely accepted that amylose-lipid complexes have a helical structure, with the linear chain of the guest lipid situated along the central axis of the helical cavity. Encapsulation of some *tejate*

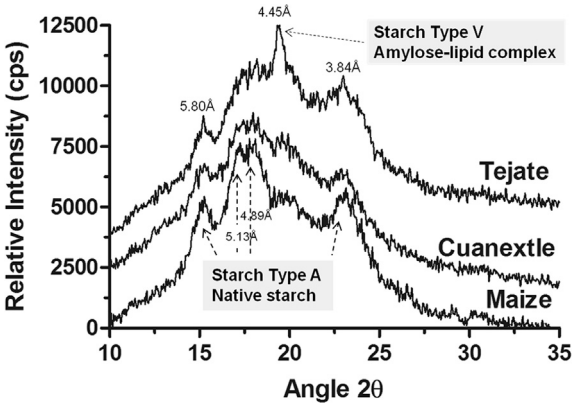

Fig. 3. X-rays diffraction patterns of tejate, cuanextle and maize.

ingredient compounds such as lipids, and antioxidants into the helical amylose cavity, can be used to stabilize volatile flavor compounds for better organoleptic taste, as well as giving the resistant starch health benefits and slowing the release of energy from amylose-lipid complex during digestion. Several authors have indicated that amylose complexes thereby increase their aromatic compound retention (Arvisenet, Le Bail, Voilley, & Cayot, 2002; Arvisenet, Voilley, & Cayot, 2002; Wulff, Avgenaki, & Guzmann, 2005). This way, however, the aroma compounds influence the complexing of free fatty acids and stabilize the ligands against oxidation, but also creates a vehicle for the controlled release of the ligand in the intestine, instead in the stomach (Conde-Petit, Escher, & Nuessli, 2006).

3.6. The effect of RS in tejate on the post-prandial blood glucose responses in humans

Relevant parameters, such as the resistant starch and GI values are listed in Table 5. The main increment of blood glucose during the 120 min following ingestion of different *tejate* samples is shown in Fig. 4. All *tejate* samples produced significantly lower blood glucose responses than the glucose control.

In fact, contrary to expectations, all *tejate* samples without sugar added showed excellent blood glucose response compared to the values reported for soft drinks, juices and sugars (Foster-Powell, Holt, & Brand-Miller, 2002; Jenkins et al., 1981). Beverages with mixed powder that include chocolate, also appeared relatively low in GI but higher than the GI values of *tejate*. However, *tejate* is usually consumed with sugar as concentrated source of energy, and in this case the better *in vitro* glucose performance was also found in *tejate* made from white Bolita and Chalqueño followed by yellow Bolita and Cacahuacintle (Table 5). The good post-prandial blood glucose responses of Bolita and Chalqueño *tejate* samples seem to be correlated with the resistant starch found in *tejate* (Table 5 and Fig. 4). Commercial *tejate* samples (*Tejatli* and *Tejayapam*), with added sugar showed relatively poor performance, as shown in Table 5. Therefore, any kind of *tejate* without added sugar should be recommended to maintain the normal post-prandial blood glucose responses.

Besides the fermentation and roasting steps for the improving quality of the cacao beans in *tejate*, there are two main technological steps that seem to be critical in maintaining the quality performance of *tejate*. The first one is the annealing that takes place during the resting or steeping the nixtamal (Figueroa, Véles, & Hernández et al., 2013). The starch annealing in nixtamal may have important implications for the stability of starch granules during processing, and for viscosity and swelling capacity of the

Table 5
Total starch and resistant starch in maize cuanextle and tejate.[a]

Sample	Total starch[b] (g/100 g)	Resistant starch[b] (g/100 g)	Glycemic index	
			No sugar added	Sugar added
Maize				
White Bolita	76.50 ± 1.66b	0.84 ± 0.01b	–	–
Yellow Bolita	77.04 ± 1.29b	0.63 ± 0.03c	–	–
Chalqueño	82.85 ± 1.07a	1.01 ± 0.02a	–	–
Cacahuacintle	75.03 ± 0.41b	0.50 ± 0.02d	–	–
Cuanextle				
White Bolita	93.27 ± 1.97a	1.02 ± 0.14a	–	–
Yellow Bolita	78.83 ± 0.12b	0.87 ± 0.01bc	–	–
Chalqueño	89.21 ± 2.44a	1.00 ± 0.01 ab	–	–
Cacahuacintle	87.58 ± 0.73a	0.74 ± 0.10c	–	–
Tejate				
White Bolita	68.63 ± 1.34b	2.43 ± 0.34a	32.71 ± 3.87a	38.21 ± 13.54b
Yellow Bolita	64.09 ± 3.72c	1.46 ± 0.04bc	29.80 ± 17.19a	41.33 ± 10.64 ab
Chalqueño	70.16 ± 0.23b	2.07 ± 0.06a	25.02 ± 19.30a	23.09 ± 14.79b
Cacahuacintle	65.79 ± 0.22bc	1.49 ± 0.17b	27.85 ± 4.18a	49.41 ± 12.67 ab
Tejatli	30.16 ± 0.13d	1.04 ± 0.15cd	–	54.32 ± 1.68 ab
Tejayapam	80.17 ± 0.59a	0.81 ± 0.00d	26.06 ± 8.09a	74.46 ± 17.19a
Glucose (control)	–	–	–	100

[a] Means ± SD followed by the same letter in the column within the same group are not significant different at $P < 0.05$.
[b] Measured by MegazymeTotal Starch and Resistant Starch kits. Resistant starch was adjusted by the total starch used.

tejate in obtaining a good beverage consistency as shown in Table 4 and Fig. 2. The second event seems to be the starch doped with different amount of minerals (Table 3) by the use of wood ashes in the Classic nixtamalization process that gave a good source of minerals to the product. Annealing and doping both seem to protect the starch granules from amylolytic hydrolysis promoting long term release of sugars which is important in maintaining a normal glucose level in blood and acting to preventing diabetes mellitus type II. Although *tejate* is made from maize with relatively high levels of carbohydrates and lipids, this research shows that part of these compounds are in the form of starch-lipids complexes (resistant starch). Several authors reported that V type starch is slowly digested by gut enzymes and are fermented in the colon after long periods of time, with distinct nutritional health benefits for the consumer (Murray et al., 1998).

4. Conclusions

Tejate is a maize product made by ash nixtamalization, instead of lime (calcium hydroxide) nixtamalization, the process used for most maize foods. The Classic Nixtamalization with ashes appears to have significantly higher content of minerals, dietary fiber and resistant starch. The thermal properties of starch in *cuanextle* (ash-masa) and *tejate* showed an increment of the gelatinization from maize to *cuanextle* and *tejate* that are typical annealing effects compared to native maize without processing. The mixture of ash-masa and cacao-masa showed the formation of starch-lipid complexes detected in the DSC thermogram. The starch-lipid complexes formed in *tejate* samples are indeed type 5 resistant starch (RS5), which has important health benefits for consumers. All *tejate* samples after ingestion produced significantly lower blood glucose response (glycemic index) than the glucose control. The results provide support for the hypothesis of a slow digestion and absorption of carbohydrate-lipid complexes from *tejate*.

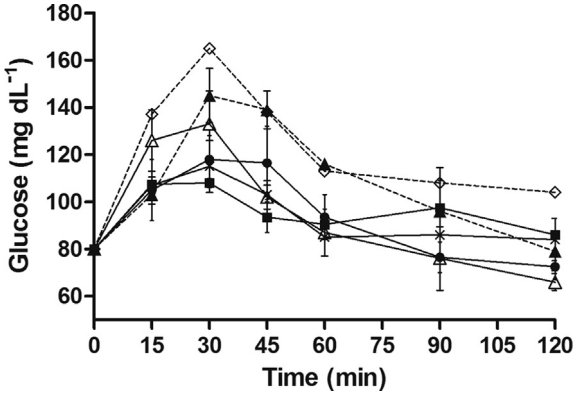

Fig. 4. Blood glucose curves (means ± SD). Rhombus and dashed line:glucose solution; close triangle and dashed line:Tejayapam commercial tejate; cyrcle:yellow Bolita; square:white Bolita; open triangle: Cacahuacintle and cross:Chaqueño.

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Physicochemical and nutritional properties of different maize landraces on totopos (toasted tortillas)

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Area of Expertise:	Resistant starch, Maize, Infrared radiation, Totopo (toasted tortilla), Texture

Physicochemical and nutritional properties of different maize landraces on totopos (toasted tortillas)

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ABSTRACT

Biodiversity contributes to nutrient production and together with processing are critical factors for product quality. Totopo physicochemical and nutritional properties were evaluated in maize landraces from Oaxaca communities and others made with maize races with different endosperm types. Texture profile shows that totopos elaborated from Zapalote Chico maize landrace showed the best performance (low breaking force) and higher crunchability similar to commercial totopos. Quality of Zapalote Chico totopos was explained by flotation index (FI) and starch viscosity as well as thermal properties. FI was negatively correlated with texture that may related to end-use. Zapalote Chico landrace gelatinizes at higher (P<0.05) pasting temperature (72.75-73.30 °C) and it had higher

(*P*>0.05) peak viscosity (4723-3093 cP), suggesting that starch granule resists better the drastic conditions during baking. In the hybrid and Tuxpeño samples most of starch granules (90 %) were gelatinized and increasing the hardness in totopos. The totopo samples increased the peak at 4.45 Å, a characteristic of type-V diffraction of amylose-lipid complexes (resistant starch). In fact, an increase of 0.6 % of resistant starch was found in totopos which has important nutritional benefits for consumers. Our results support the preference of Oaxaca people for the totopos made from Zapalote Chico maize.

Keywords: Resistant starch, Maize, Infrared radiation, Totopo, Texture.

INTRODUCTION

Food, as well as the processing, has a significant impact on human health, therefore food and nutrition, dietary adequacy and biodiversity are currently amongst the most vigorously discussed global topics in the field of nutrition (Jones et al. 2013).

Mexico is the center of origin of maize the crop has been Mesoamerica's basic staple for at least two millennia (Goodman 1998) and is the core of dynamic cultural traits (Hernandez 1985). For centuries, people in Mexico and South America developed new maize varieties, adapting them not only to local conditions but also to their special cultural and culinary needs (Anderson, 1946; Figueroa et al 2013a). Most maize products at industrial and domestic levels are elaborated using the nixtamalization process, among those foods are the totopos, tortillas, tortilla chips, tamales, and pozole (Figueroa et al 2013a).

The name totopo is derived from the Nahuatl ***totopo****chtl* that means toasted (Simeón, 1977). In Mexican cuisine totopos may be specially prepared, as the case we will describe, or they can be done with stale tortillas that are reheated until toasted in a comal (hot iron plate), an

oven or deep fried. The later are commonly known as *tostadas* in Mexico, but in some cases these fried tortilla chips are commercially made and are labeled or referred to as totopos both in Mexico and the United States, although they are not made in the manner of the Oaxacan totopos we describe. The best known totopos in Mexico are done by the Zapotec people in the Isthmus of Tehuantepec region of state of Oaxaca. There, the Zapotec women bake totopos in a bottomless clay oven without cover known as *comizcal* or *comixcal* (Figure 1). The baking involves the use of infrared radiation, a process developed by Zapotec people of Oaxaca. This infrared radiation oven gives a unique texture taste, and nutritional properties to the totopos. These special kind of totopos are considered a specialty, have important demand in major cities of Mexico and the United States, and are the subject of the present research.

Although the infrared (IR) was classified recently as an important emerging food technology, the use of IR technology in the preparation of food and especially totopos in Oaxaca back several hundred years ago. The infrared heating involves the exposure of a material to electromagnetic radiation in the wavelength region of 1.8-3.4μm. For biological materials, the penetration of IR rays into the material causes the water molecules to vibrate at frequency of 60,000-150,000 MHz. This causes rapid internal heating and water dissipation from the material (Fasina et al 2001).

With the increasing popularity of Mexican corn-based cuisine in the United States and in all the world, there is special interest in investigations in the alkaline cooking methods and processing in formation of resistant starch (RS). Despite the popularity and economic importance of totopos in Oaxaca, Mexico and US, the characteristics that maize should have for good quality totopos are not well known.

Maize scholars have considered that the particular maize types traditionally used for different specialty products should be better than alternative varieties, some consider that this is a major reason for on-farm conservation of traditional landraces of maize (Anderson 1946, Hernandez-X 1985; Ortega-P 2003). In the Zapotec region where the totopos are made the dominant maize race is known as Zapalote Chico, it is particular to the Isthmus of Tehuantepec region, with only sporadic presence in other areas (Perales and Golicher 2014). Thus, it is straightforward to suppose that maize of this race is required for the production of totopos, or that the best totopos are done with varieties of this race. In fact, local consumers commonly mention their preference of totopos produced with traditional landraces of Zapalote Chico.

In Mexico the term landrace and race are not interchangeable. A landrace is a crop population with historical origin, distinct identity and that lacks formal crop improvement (Camacho et al 2006). Racial classification of maize has sought to be a natural classification that could reflect the history and relationships of maize populations. Originally proposed by Anderson and Cutler (1942) it was formalized by Wellhausen et al (1952) and is still widely used to study maize diversity in Mexico (Sanchez et al 2000; Vigouroux et al 2008). Presently it is considered that there are about 60 races in Mexico (Sanchez et al 2000). In Mexico, all landraces can be classified in a racial category and some races have both landraces and formal commercial cultivars.

Even though Zapalote Chico landraces are commonly used for the manufacture of totopos, local production is not enough for the demand of totopos and other maize varieties are bought in regional markets. The most common maize types available in though markets are commercial cultivars, but landraces of the Tuxpeño and Chalqueño races are also

available. We do not have information as to the suitability of these maize races and commercial cultivars for the production of totopos.

Therefore, the aim of this research work was to investigate physicochemical and nutritional characteristics on totopos, using samples including totopos prepared in the Zapotec communities of Oaxaca and in the laboratory, and using different maize races and commercial cultivars with traditional recipe and equipment.

MATERIALS AND METHODS

Materials

We used two collections of Zapalote Chico and one of the Tuxpeño and Chalqueño races acquired in the community of San Blas Atempa, Oaxaca; the last two were from a community store and the Zapalote Chico were from local farmers in Atempa (these will be referred as Zapalote Chico 1 and Zapalote Chico 2. The Chalqueño was probably a landrace because commercial cultivars of this race are very rare (Perales et al 2003), in the case of the Tuxpeño it is uncertain because many landraces and commercial cultivars are widely cultivated. The commercial hybrid 30G54 of Pioneer was acquired from the market in the city of Querétaro, Mexico. We considered the hybrid as a control for its contrasting floury texture. Samples were stored in a cold room at 4°C. Two totopo samples prepared by local women in the Tehuantepec Isthmus of Oaxaca were included, a homemade totopo sample from San Blas Atempa (referred here as San Blas) and a commercial totopo sample from Tehuantepec (referred here as Tehuantepec), Oaxaca; both were done with Zapalote Chico landraces.

Chemical Composition

Moisture was analyzed according to the AACC International (2001) method AACC 44-19.01; ash according to method AACC 08-03.01; fat according to method AACC 30-25.01; protein according to method AACC 46-13.01; and crude fiber according to method AACC 32-10.01; Total starch AACC method 76.13; Resistant starch AACC method 32-40.01. Carbohydrate content was calculated on dry weight basis as followed: 100-(protein content + ashes + fat + fiber). Metabolizable energy using the Atwater conversion factors for cornmeal whole ground: protein 11.4 kJ/g (2.73 kcal/g), fat 35 kJ/g (8.37 kcal/g), carbohydrate 16.9 kJ/g (4.03 kcal/g) (FAO 2003). The conversion factors for joules and calories are: 1 kJ = 0.239 kcal; and 1 kcal = 4.184 kJ.

X-ray Diffraction

All samples with 7% moisture content were placed on a glass surface and scanned from 5 to 50º on the 2θ scale using a Rigaku X-ray diffractometer DMAX-2100, which operates at 30 kV and 16 mA with a CuKα radiation of $\lambda = 1.5405$. The interplanar spacings (d) of the peaks were calculated using the Bragg equation $n\lambda = 2d \sin \theta$ (Figueroa et al 2013a).

Pasting Properties

A Rapid Visco-Analyzer (RVA) (3C Model Newport Scientific PTY LTD, Sydney, Australia) was used to determine the viscoamylographic curve. The method used was that reported by Narváez-González et al (2006a).

Thermal Properties

A calorimeter (821 Model DSC Mettler Toledo, Ejército Nacional 340, Col. Chapultepec Morales, Mexico DF C.P. 11570) equipped with a thermal analysis data station was used. The method reported by Narváez-González et al (2006b). Each sample was run in duplicate.

Degree of gelatinization was calculated according to Baks et al (2007).

Totopo preparation

In Figure 2 we show the flowchart for producing totopo, the recipe is based on our field work in San Blas Atempa. We followed this recipe in our laboratory procedures, with the exception of baking, which was not done in a comixcal (see next section).

IR-Baked Totopos at Lab

An IR oven for baking totopo was built in our laboratory (Fig. 3) in Querétaro (González-Hernández et al 1996). Masa with adequately consistence was shaped into disks of 127mm of diameter and 2.6 mm thick using a manual roller machine (Casa González, Monterrey, NL, México). The uncooked totopos were then placed on a continuous band made of stainless steel mesh of no. 18 wire gauge, providing 18 squares per inch as a means of conveying the products to the IR baking apparatus.

The preferable wavelength was 2.5–4.0 μm to allow for the best coupling of the IR frequency with the masa (dough) IR absorption. The four resistive heat emitters were arranged such that two faced, each 61cm in length, 0.95 cm in diameter, and spaced at 2.5 cm intervals. The emitters of each array were round and made from a Ni-Cr alloy covered by a stainless steel sleeve and isolated with a MgO ceramic material (Fig. 3). They were supported by a frame of stainless steel material and covered by an IR reflector made of

polished stainless steel. The electrical power delivered to the heaters was ≈900 W each and was controlled with switches (González-Henández, et al 1996). The whole baking system was enclosed in a thermally insulated box. The power irradiated by the emitter elements was of 20 Watt/cm^2. The power level of the IR energy was set in order to allow the drying of both totopo sides. Under these conditions, the totopo was dehydrated within 20 to 30 seconds to reach a moisture content of about 7-8 %.

Totopo hardness and Elastic modulus

Hardness.

A TA-XT2 Texture Analyzer (Texture Technologies Corporation, Stable Micro Systems; Surrey, England) was used with a TA-52 probe with 2mm diameter. Each one of five totopo samples were punctured at 0.5 mm s-1 to a depth of 2 mm. The test was performed in duplicate in each sample.

The elastic modulus of totopos

Tablets of 0.42 mm heigh and 8.07 mm diameter (contact area of 51.52 mm^2) were sintered from totopo milled samples following the procedure described by Figueroa et al (2016). For each tablet 0.3 g of the sample was weighed into a 10 ml beaker sealed with parafilm and placed in a controlled temperature chamber at 20°C for 2 h. The tablet-forming die of hardened steel had an inside diameter of 7.95 mm, and a length of 31.69 mm. Two hardenes steel dowels were used to apply the pressure necessary to form the tablets. The sample was transferred into the die, the upper dowel placed into the lower die and the set positioned onto a table with hydraulic press (Trupper 501 of 50 tonnes

capacity). The load on the die was gradually increased to reach 25 tonnes and mantained for 5 min before removing the tablet from the die.

A TA.XT Plus texture analyzer with a 25,000 g load cell (Texture Technologies, Scarsdale, NY/Stable Micro Systems, Surrey, England) was used to measure the tablets response to compressive loadings using parallel plates. Before loading, the thickness of each tablet was determined with a caliper. In the stress relaxation test, a displacement of 0.3 mm was applied over a specified ramp time of 25 points/sec and loading rate of 0.1 mm/s, after which the displacement was held constant during the stress relaxation phase of 100 s. The reaction force and stress-time history were recorded. Each data point was an average of six readings from different totopo tablets of the same sample for each replicate (Figueroa et al 2013b).

Statistical Analysis.

Simple Pearson's correlations were classed as significant at $P \leq 0.05$. The means comparison in a one-way analysis of variance was carried out and multiple range test were performed using Duncan's test with Statistical Analysis System software (SAS Institute 2009).

RESULTS AND DISCUSSION

Physicochemical properties of maize samples

Table I shows that Zapalote Chico has a relatively soft and lower density kernel as indicated by the flotation index (75.15) and test weight (71.15 kg/hL), compared to Tuxpeño, Chalqueño and the hybrid. The Chalqueño kernel has heavier kernel weight (393 g) and test weight (73 kg/hL), these characters relate to higher flour and masa yields once

processed. The physical features TKW and FI of Zapalote Chico and Tuxpeño agreed with the values reported by Narvaez-Gonzalez et al., (2006a) and with data of kernel length, wide and thickness as well as TKW of Chalqueño, Tuxpeño and Zapalote Chico reported by Figueroa et al (2013c).

Physical properties of totopo samples

Table II shows that Zapalote Chico and Chalqueño had whiter L color in totopos. The samples of Chalqueño and the hybrid maize produced thinner totopos, which might reflect greater compaction when cooked. All totopos made in the laboratory were processed in a similar way by controlling the diameter at 127 mm and the gap between rolls 2.6 in a commercial tortilla machine of 2.6 mm to have the average thickness of the totopos we bought in Oaxaca. The laboratory totopos showed a diameter reduction of 13.3% form wet totopos to baked totopos without significant differences among them.

Regarding totopo texture profile Figure 4A shows that totopos elaborated from hybrid maize showed the harder texture followed by Tuxpeño and Chalqueño and the softer texture and crunchability were for the samples of Zapalote Chico 1 and 2. The Tehuantepec totopo samples showed soft texture but less crunchability as indicated by the number of peaks in the texture profile. The totopo hardness (breaking force) is explained by the kernel hardness as indicated by the flotation index, where the hybrid showed the lower value (hard kernel) followed by Chalqueño and Tuxpeño and the softer kernel was Zapalote Chico 1 (Table I).

Gaytán et al (2006) reported significant differences in some physical (flotation index, density, endosperm type), and microstructure (starch granule size, cell packing) characteristics between hard and soft corn kernels, where flotation index was negatively

correlated with hardness that may affect the end-use. The present data agrees with the stated preference of Oaxacan people and Figueroa et al (2013c), who indicated that Zapalote Chico has a softer kernel maize when compared to most of the Mexican maize landraces. Wellhausen et al., (1952) indicated that Zapalote Chico presented mostly soft starch. Additionally, the reported low water absorption capacity, kernel hardness and microstructural features (starch granule compaction and size) of Zapalote Chico made this landrace an excellent maize for elaboration of toasted snack products (Narváez-González et al 2007; Figueroa et al 2013c).

Rheological and Thermal Properties of Annealed Starch in maize, masa and Totopo

Starches in maize, masa and totopos were characterized using thermic and rheological properties in order to explain quality differences. The outcome (starch viscosity and gelatinization temperatures) are indeed a consequence of microstructure (flotation index, hardness) and in minor extent of chemical composition since thermal and rheological features depend mainly from these.

Figure 4 show that there is a relation between the typical texture and viscosity profiles. The hard texture totopos were found in samples of maize and totopos with low viscosity. More details can be observed in Table IV, where the poorest rheological (low peak viscosity) and thermal performance was shown by Hybrid followed by Tuxpeño. These samples presented the higher totopo elastic modulus (hardness) compared to the other maize samples. Chalqueño and Tuxpeño starches presented a regular rheological performance and quality. In the hybrid and Tuxpeño samples most of starch granules presented high degree of gelatinization (90 %) that increased the hardness in totopos. Zapalote Chico presented higher peak viscosity and pasting temperature in maize and

totopo samples comparable with the Tehuantepec totopo sample, but not to that of San Blas. Starch in Zapalote Chico grains gelatinizes at a higher pasting temperature (72.75-73.30 °C; P < 0.05) and it has a very high peak viscosity in Zapalote Chico 1 (4723 cP; *P* < 0.05), though in the case of Zapalote Chico 2 peak viscosity was only higher than the hybrid (Table IV).

Besides the nixtamalization and baking, which are important technological issues for improving the quality in totopos, there is an important step that seems to be critical in maintaining the quality performance of totopo. This is the annealing that takes place during the resting or steeping the nixtamal (Figueroa et al., 2013a) and is dependent on the maize genotype. The nixtamalization process enhances the viscosity, swelling and starch granule stability to collapse, that behavior suggests that starch granule anneals during the nixtamalization. Several authors indicated that annealing takes place when starch is heated, in excess of water, for a certain period of time at temperatures below gelatinization and, thus, starch undergoes reorganization to a more ordered structure (Krueger et al 1987; Gómez et al 1992; Campus et al 1999; Quintanar et al 2011; Figueroa et al 2013a). The data shown in Table IV are in agreement with previous published reports that indicated that traditional nixtamalized products presented higher thermal properties than raw samples (Campus-Baypoli et al 1999; Rendón-Villalobos et al 2002; Ratnayake et al 2007).

The higher peak and final gelatinization temperatures in Zapalote Chico starch in maize and totopos, suggest that Zapalote starch granule resists better the drastic conditions during baking.

Effect of maize landraces and processing on proximate composition and nutritional aspects on totopos

Besides starch that seems to play major role in explaining the textural properties in totopos, there were no clear relation of fiber and fat and other chemical compounds in texture. However, those chemical compounds of maize are important from the nutritional point of view. The changes of chemical components in totopos compared to the counterpart maize landraces are due to the cooking losses during nixtamalization and totopo baking into comixcal or IR oven (Table III). As result of these processes, some nutrients are lost, including vitamins, fat, dietary fiber and some minerals (Bressani 1958, 1972; Gómez-Aldapa et al 1996; Maya-Cortés et al 2010). Totopo samples showed about 1.0 % higher protein, 2.0 % lower lipids, as well as and 1.0 % lower fiber than the counterpart maize samples may be explained by differences in pericarp losses during nixtamalization process reported by several authors (Campechano et al 2012). Similar data was reported for Chalqueño landrace from Oaxaca for protein, ash, lipids, carbohydrates, and total starch as well as energy (González-Amaro et al 2015). Rooney and Serna-Saldívar (1987) mentioned that cooking corn with the alkaline thermal process results in losses in proteins and dietary fiber.

Part of the lipids in totopos are in the form of amylose lipid complexes (resistant starch) that are resistant to enzymatic attack and relatively high temperatures (90° to 130 °C). Figueroa et al. (2013a), indicated that the naturally occurring fatty acids and phospholipids can become complex with the amylose fraction at high temperatures. Selected conditions might include combinations of high moisture levels >18-45 % w/w, temperatures of 90-130 °C, and holding time of 1-16 h (Zobel, 1988) similar to those used for making totopos. The decrement of crude fiber form maize to totopo was due to loss of pericarp in the nixtamalization. According to Gutiérrez et al (2010), the combination of heat and alkali during traditional nixtamalisation acts aggressively on the outer layers of the pericarp and

promotes partial removal of hemicelluloses and partial lignin from the fiber matrix of the pericarp. This data agrees with the report of Campechano et al (2012), who reported losses of pericarp of about 2-6 %. An increase of almost 1.0 % of resistant starch in totopos was also observed (Table III).

González-Amaro et al (2015) indicated that starch-lipid complexes or resistant starch (RS), are also detected as V type starch using X-ray diffraction and they have important health benefits for consumers since their consumption maintain blood in normal glucose levels. The dietary incorporation of V-complex to replace traditional carbohydrates may be beneficial for diabetic patients because of the decreased digestibility and subsequent glucose absorption rate (Murray et al 1998). Therefore, resistant starch is emerging as an important dietary component that has the potential to reduce the incidence of bowel health disorders (Morrell et al 2004).

X-ray diffraction patterns starch type A and starch type V

The X-ray diffraction showed peaks at 5.8 Å, 5.1Å and 3.8 Å of type A starch pattern described by Zobel (1988) decrease in starch from maize and masa annealed starch and those peaks characteristic of Type A starch disappeared in totopos (Figure 5).

The processing of masa for totopo increased the peak at 4.45 Å, a characteristic of type V diffraction of amylose-lipid complex (RS). The decrease in peaks of amylopectin in maize and masa suggests that side branches of amylopectin form new amylose helices (Zobel, 1988) as indicated by the increase of amylose peak at 4.45 Å (Figure 6) which is in the form of complexes, as seen by X-ray. These data agree with (Pérez and Bertoft 2010) who indicated that the starch–lipid complex in an amorphous state can be changed into a more ordered semicrystalline V-type diffraction (Fig. 5). The implications of those changes in the

processing parameters and in the nutritional quality of final totopo products require additional investigations.

CONCLUSIONS

Parameters such as flotation index (hardness) and viscosity of starch suspensions as well as the thermal properties explained most of the quality in totopos.

The best performances related to softer texture (lower breaking force and elastic modulus) and higher crunchability were found in maize landraces and their totopos with higher viscosity and gelatinization temperatures suggesting that starch granule resists better the drastic conditions during baking.

During processing, the chemical composition of corn, masa and totopo, thermal properties and X-ray diffraction indicate that formation amylose-lipid complexes or resistant starch.

The implications of those changes in the processing parameters and in the nutritional quality of final totopo products require additional investigations. Our results support the preference of the people of Oaxaca for the totopos made from Zapalote Chico maize when compared with other maize types.

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Table I. Physicochemical properties of maize samples

Samples	Length (mm)	Wide (mm)	Thickness (mm)	Moisture (%)	TKW (g)	TW (kg/hL)	FI	Color (L)
Zapalote Chico 1	12.13±0.89b	9.98±0.75a	3.72±0.46b	14.72±0.08a	260.52±7.01d	71.15±0.60c	75.67±0.58a	68.72±1.38d
Zapalote Chico 2	12.15±0.52b	9.22±0.47ab	3.57±0.32b.	12.42±0.02d	245.80±3.49d.	70.76±0.34c	62.75±3.86b	66.62±0.20d
Tuxpeño	13.10±0.94a	8.69±0.83b	4.40±0.57a	13.66±0.20c	329.50±16.82c	73.55±0.34b	33.00±3.61d	63.52±2.05c
Chalqueño	13.15±0.71a	8.78±0.71b	4.54±0.54a	15.11±0.25a	393.15±5.21a	72.97±0.33b	39.33±3.06c	60.60±0.69a
Hybrid	12.42±0.00b	8.36±0.00c	4.30±0.00a	14.18±0.09b	351.58±0.01b	76.00±0.71	5.00±0.09e	62.20±0.51b

Means followed by the same letter in the same column are not significant different Duncan ($P<0.05$).

TKW=Thousand kernel weight; TW=Test weight; FI=Flotation index; L=Luminosity.

Table II. Physical properties of totopos.

Sample	Totopo Color L	Thickness (mm)	Diameter (mm)
Zapalote Chico 1	75.61±0.84a	2.59±0.16a	109.54±1.62b
Zapalote Chico 2	76.59±0.24a	2.63±0.19a	110.01±0.86ab
Tuxpeño	72.86±1.90b	2.60±0.16a	110.89±0.98a
Chalqueño	76.08±1.02a	2.30±0.20b	110.84±2.05b
Hybrid	74.13±0.80b	2.17±0.10c	109.35±1.70b
San Blas	72.23±2.67	3.33±0.32	142.37±2.68
Tehuantepec	68.52±1.75	1.73±0.23	132.86±4.03

Means followed by the same letter in the same column are not significant different Duncan ($P<0.05$).
L=Luminosity.

Table III. Proximate chemical composition and nutritional properties of maize, masa and totopo samples[a].

Sample	Protein (%)	Ash (%)	Lipids (%)	Crude Fiber (%)	CHO (%)	Energy Kcal/100g	Energy kJ/100g	RS[c] (%)	TS[c] (%)
MAIZE									
Zapalote Chico 1	7.00±0.0ab	1.50±0.00a	5.13±0.14b	1.48±0.00b	84.89±0.14a	404±1a	1694±3a	0.91±0.01a	85.29±1.86a
Zapalote Chico 2	7.37±0.18a	1.40±0.14ab	5.25±0.03b	1.58±0.00a	84.40±0.01b	404±0a	1694±1a	1.11±0.33a	77.24±0.64a
Tuxpeño	6.16±0.40c	1.15±0.07c	4.58±0.12c	-	-	-	-	0.64±0.41a	75.04±2.88a
Chalqueño	6.69±0.09b	1.30±0.00abc	4.78±0.12c	-	-	-	-	0.67±0.04a	82.79±8.39a
Hybrid	7.19±0.00ab	1.25±0.07bc	5.52±0.07a	-	-	-	-	0.66±0.03a	84.17±0.57a
MASA									
Zapalote Chico 1	7.72±0.04b	1.10±0.00b	4.71±0.02a	0.45±0.06b	86.06±0.13c	407±0a	1708±1a	0.92±0.06b	70.13±0.14c
Zapalote Chico 2	8.50±0.09a	1.20±0.00ab	4.81±0.16a	0.54±0.07b	84.99±0.04d	406±1ab	1702±5ab	0.85±0.01b	86.28±0.89a
Tuxpeño	6.62±0.18c	1.10±0.014b	4.06±0.13b	0.49±0.13b	87.63±0.57a	405±1b	1700±3b	0.97±0.14b	83.63±0.75b
Chalqueño	7.66±0.22b	1.15±0.07ab	4.13±0.19b	0.40±0.00b	86.66±0.04b	405±1b	1697±4b	0.89±0.01b	81.88±1.41b
Hybrid	7.81±0.00b	1.39±0.13a	3.85±0.11b	0.34±0.06b	86.64±0.04b	403±1c	1688±3c	0.97±0.00b	87.51±1.51a
San Blas[b]	6.66±0.13c	1.10±0.14b	3.50±0.01c	1.28±0.06a	87.46±0.07a	400±1d	1677±3d	1.53±0.15a	82.16±0.03b
TOTOPO									
Zapalote Chico 1	8.03±0.03a	1.30±0.00bc	3.36±0.27abc	0.44±0.07de	86.87±0.11b	400±2a	1677±8a	1.89±0.02a	69.08±1.53bc
Zapalote Chico 2	8.53±0.44a	1.20±0.00bc	3.43±0.37abc	0.50±0.14d	86.58±0.33b	400±2a	1676±7a	1.33±0.01cd	90.22±0.18a
Tuxpeño	7.59±0.13ab	1.10±0.14bc	2.73±0.37c	0.40±0.01e	88.18±0.11a	398±2a	1672±10a	1.19±0.25de	65.57±0.72bcd
Chalqueño	7.75±0.18b	1.15±0.21bc	3.52±0.46abc	0.69±0.00c	86.89±0.42b	401±3a	1680±11a	1.16±0.14de	64.39±4.41cd
Hybrid	7.19±0.27c	1.05±0.07c	4.13±0.37a	-	-	-	-	1.00±0.01e	64.99±0.39bcd
San Blas[b]	-	1.35±0.08b	3.03±0.23bc	0.79±0.00b	-	-	-	1.70±0.00ab	70.32±0.86b
Tehuantepec[b]	-	1.75±0.07a	3.62±0.07ab	0.88±0.00a	-	-	-	1.55±0.08bc	61.74±3.10d

[a]Means followed by the same letter in the same column within the same group are not significant different at P<0.05.
[b]San Blas and Tehuantepec were masa and totopo made by local women in the Isthmus of Tehuantepec region.
Data reported in dry basis. CHO= Carbohydrates; RS= Resistant Starch; TS= Total Starch.
[c]Measured by Megazyme Total Starch and Resistant Starch kits. Resistant starch was adjusted by the total starch used.

Table IV. Effect of starch annealing on thermal properties from maize to totopo and viscoelastic properties of final product[a]

Sample	Pasting Temp (°C)	Peak viscosity (cP)	Set back (cP)	Viscosity Maxium (cP)	To (°C)	Tp (°C)	Tf (°C)	ΔH (J/g)	Elasticity Modulus MPa
Maize									
Zapalote Chico 1	72.75±0.21a	4723±119a	2388±83a	3578±3108a	67.78±0.08a	72.28±0.024b	77.40±0.00b	7.49±0.00a	.
Zapalote Chico 2	73.30±0.00a	3093±21d	1899±52c	4815±191a	68.32±0.38a	73.46±0.21a	79.41±0.21a	6.73±0.01ab	.
Tuxpeño	69.95±0.49b	3664±107c	2129±25b	6416±208a	63.78±0.40b	69.38±0.35c	75.90±0.28c	5.56±1.15bc	.
Chalqueño	68.37±0.32c	4145±73b	2055±5b	6559±49a	59.37±0.11d	67.21±0.11d	74.58±0.33d	5.26±0.48bc	.
Hybrid	67.60±0.28c	2378±71e	1343±43d	3910±8a	60.28±0.48c	67.61±0.26d	76.12±0.04c	4.86±0.29c	.
Totopos									
Zapalote Chico 1	72.32±0.32b	1175±16bc	1014±16b	2100±41b	70.09±0.049ab	76.01±0.025b	81.99±0.21b	0.84±0.17ab	3.33±0.58dc
Zapalote Chico 2	72.15±0.00b	1278±11ab	1021±4b	2274±1b	70.30±0.52ab	76.50±0.96b	82.22±0.68b	0.95±0.06a	3.36±0.61dc
Tuxpeño	69.42±0.74c	1054±30c	982±43b	2142±70b	66.57±1.42ab	72.51±0.01bc	79.77±0.18bc	0.54±0.13abc	5.13±0.43a
Chalqueño	69.25±0.07c	1335±106a	1197±88a	2699±250a	64.02±1.22b	70.25±0.59bc	77.48±2.56bc	0.63±0.41ab	4.52±0.70ab
Hybrid	69.20±0.00c	1089±10c	1045±6b	2081±8b	65.17±0.03b	71.75±0.12bc	78.59±0.54bc	0.48±0.01bc	4.68±0.11a
San Blas	67.60±0.28d	.	.	1700±0c	63.30±9.31b	68.32±6.83c	72.00±7.93c	0.00±0.00d	2.60±0.14d
Tehuantepec	73.45±0.78a	.	.	1490±87c	75.70±3.10a	83.49±2.33a	90.46±0.76a	0.13±0.04cd	3.87±0.27bc

[a]Means followed by the same letter in the column within the same group are not significant different (P>0.05).

To=Onset gelatinization temperature; Tp=Peak gelatinization temperature; Tf=Final gelatinization temperature; ΔH=Enthalpy of gelatinization.

Figure 1. A cay hot oven (Comixcal or Comizcal) for preparing totopos by IR radiation.
169x127mm (72 x 72 DPI)

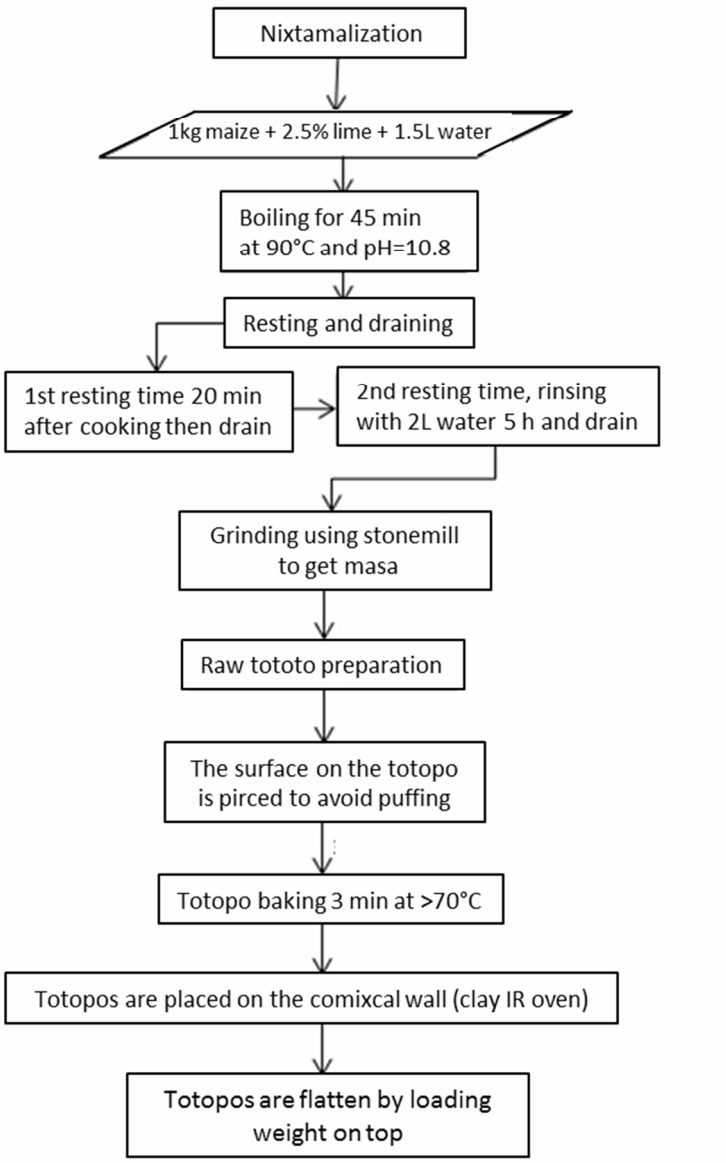

Figure 2. Traditional totopo preparation, including the nixtamalization and IR drying using the comixcal (clay IR oven).
106x168mm (149 x 149 DPI)

Figure 3. Infrared oven US Patent 5,567,457 (González-Henández et al 1996), used to elaborate the totopos (right side). Totopos with little holes made with either a finger or a comb, which prevents the fresh masa from ballooning up as they bake.

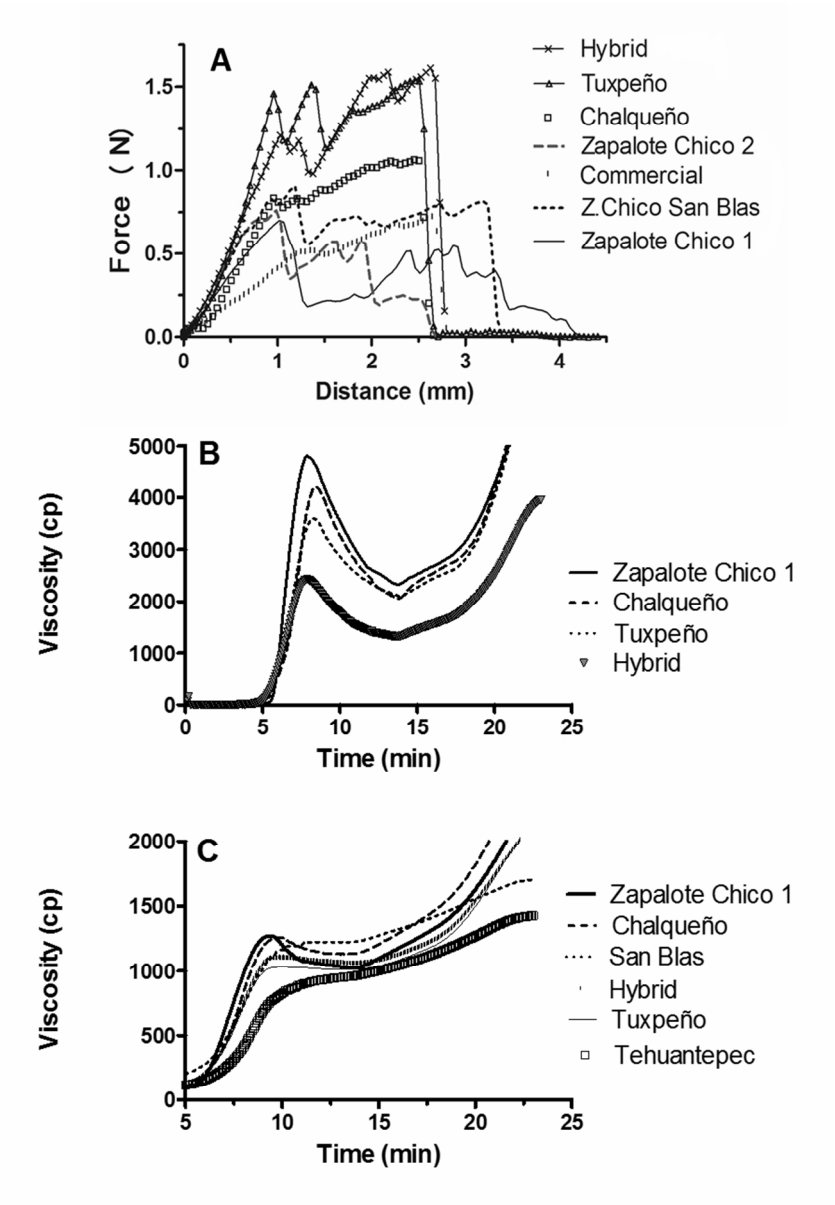

Figure 4. A. Typical texture profile of totopos (normalized at 2.6 mm totopo thickness). B. Maize and C. Totopo viscoamylographic profiles of water suspensions.
152x219mm (149 x 149 DPI)

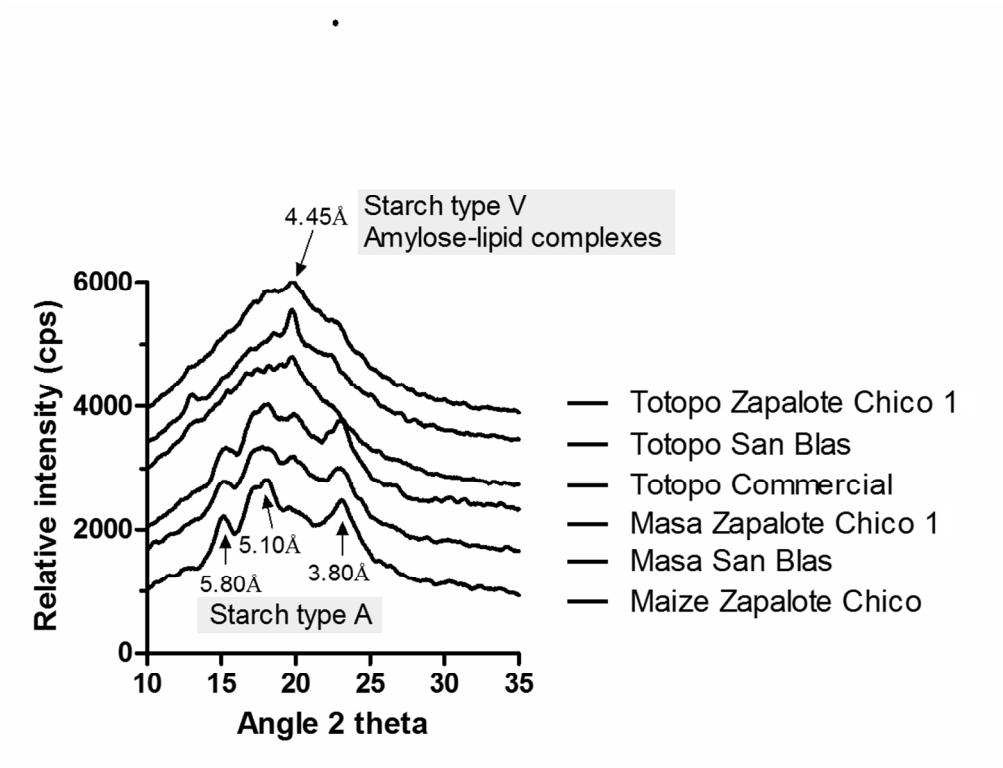

Figure 5. X-rays diffraction patterns of maize, masa and totopos. Patterns are shifted along the linear intensity axis for clarity by adding constants of 500 cps (counts per second) to each pattern.
210x160mm (149 x 149 DPI)