UTILIZATION OF AUTOCLAVED LABLAB FLOUR

IN

PRODUCTION OF SAUSAGES

By

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DEDICATION

To my family members, mother, three brothers and sister who lightened and paved the pathway to all success, I have attained in my life, this effort is dedicate.
ACKNOWLEDGEMENT

I would like to express my sincere appreciation and deep gratitude with especial respect to my main supervisor Prof. Elamin A. Elkhalifa, Dean of Sugar Institute, University of Gezira for his kindness, understanding unlimited help, inspiring guidance, and critical supervision during the whole research period and during the preparation of this thesis.

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ABSTRACT

The possibility of using autoclaved unpeeled lablab bean (Dolichos lablab L.) flour (UPLF) and autoclaved peeled lablab bean flour (PLF) in comparison with potato flour (PF) at the level of 8% to replace part of the meat in coarse beef sausage were studied. The chemical and quality characteristics of these sausages were determined.

Batters containing UPLF and/or PLF flour showed increased (P<0.05) pH and protein level.

The use of autoclaved UPLF or autoclaved PLF in sausage gave higher (P<0.05) value of cooking loss and jelly separation at 0-day, but experienced lower (P<0.05) purge accumulation at 7 days of storage at 2°C in comparison to control. Autoclaved PLF decreased (P<0.05) jelly separation at 7-day storage and fat separation at 0-day and 7-day storage. Sausages containing autoclaved PLF had higher (P<0.05) scores in acceptability to sensory panel, while sausages containing autoclaved UPLF was less (P<0.5) acceptable to sensory panel. Autoclaved lablab flour did not influence (P<0.05) the texture, colour, and flavour of the finished product.

Autoclaved UPLF and/or PLF has a potential use as non–meat protein additive, that can be utilized as an extender and binder in comminuted meat products such as sausages.
الملخص:

تم إجراء البحث في إمكانية استخدام دقيق اللوبيا العفن المقشور وغير المقشور المعامل بالعجاف الذاتي (أوتوكلاف) بنسبة 8% في إنتاج السجوك. تم تحديد الخصائص الكيميائية والتنوعية للسجوك.

خلطة السجوك التي تحتوي على المضادات الغنية بالبروتين أظهرت زيادة في الرقم الهيدروجيني (pH) ونسبة البروتين.

إن استخدام دقيق اللوبيا العفن المقشور وغير المقشور المعامل بالأوتوكلاف أدي إلى فقدان نسبة عالية من الماء والزيت نتيجة لطبخ السجوك بواسطة البخار، وإنفصال نسبة عالية من الهلام من خلطة السجوك قبل التخزين. وبعد التخزين لفترة سنة أيام في درجة حرارة 2°C انخفضت نسبة إنفصال الماء والهلام في السجوك بالمقارنة مع عينة التحكم. استخدم دقيق اللوبيا العفن المقشور المعامل بالأوتوكلاف أدي إلى تخفض نسبة الهلام الذي انفصل من خلطة السجوك عند تخزينه لمدة 7 أيام وانخفاض نسبة الزيت الذي انفصل من خلطة السجوك قبل وبعد التخزين.

السجوك الذي يحتوي علي دقيق اللوبيا العفن المقشور المعامل بالأوتوكلاف أجرز أعلى النقط من حيث تقبله في الاختبار الحسي بينما السجوك الذي يحتوي علي دقيق اللوبيا العفن غير المقشور أقل تقبلاً للعازفين. استخدم دقيق اللوبيا المعامل بالأوتوكلاف لم يؤثر علي النهار، اللون والنكهة للسجوك.

إن دقيق اللوبيا العفن المقشور وغير المقشور المعامل بالأوتوكلاف يعتبر من المضادات الغنية بالبروتين والذي يمكن استخدامه كمادة تساعد علي التمسك والالتصام والاجتماع في منتجات اللحوم المقرمة كالمحمص.
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1. INTRODUCTION

Comminuted meat products are widely consumed throughout the world, but unfortunately their cost, especially for the developing countries, is high.

The increasing cost of animal protein and the fact that the availability of meat is scarce in some countries have urged researchers to explore the possibilities of utilizing different types of unconventional protein sources in comminuted meat products in order to reduce the formulation cost.

Plant protein have been used in meat products with soy bean being the major source of the protein (Katsaras and Peetz, 1994). Other vegetable sources were found to possess a potential to substitute part of the meat proteins like sunflower flour (Wills and Kabirullah, 1981), chickpea flour (Verma et al., 1984), Lupin protein in frankfurters (Alamanou et al., 1996), or wheat germ flour (Gnanasambandam and Zayas, 1992) and corn germ protein (Zayas and Lin, 1988) were also used in meat products.

Lablab bean (Dolichos lablab) was already widespread in many developing countries. Utilization of lablab bean as a source of non meat protein in meat products has been reported.

Considering the advantages of the availability of this seed and the need for low cost, nutritive meat products, an investigation on the utilization of lablab bean in comminuted meat products is needed. The possibility of using cowpea flour and lablab flour to replace part of the meat in meat products was studied (Elkhalifa et al., 1997).

The presence of antinutritional factors such as trypsin inhibitor, toxic cyanogenetic glucoside, haemagglutinins and its hard to cook property may limits lablab bean use in the human food
NAS, 1979), but this problem could be remedied by the way that, trypsin inhibitor and haemagglutinins were broken by heat and a toxic cyanogenetic glucoside soluble in the cooking water (NAS., 1979).

Elkhalifa et al. (1997) proved that about 98% reduction in trypsin inhibitor activity (TIA) when autoclaved at 121°C and 15Lb for 20 min was achieved, and heat treatment changed the functional properties of lablab bean flour to be used in food processing.

The oligosaccharide such as verbascose which was detected in lablab bean (Elhardallou et al., 1995) was reduced significantly by heat treatment (Mansour and Eldawy, 1994).

The main objectives of the research project were:

1- To evaluate the use of autoclaved lablab bean flour as non-meat additive in sausages.

2- To enhance the functional properties of the product.

3- To minimize the cost of sausage formulations especially for the developing countries.

4- To improve the nutritional value of the product.

5- To determine the proximate composition of sausages batter with autoclaved peeled lablab bean flour, autoclaved unpeeled lablab bean flour, and batter with potatoes as commercial use.

6- To study the effect of processing on the products.
2. LITERATURE REVIEW

2.1 Sausages

2.1.1 Origin

Sausages are meat products that are salted and usually seasoned. The name is derived from the Latin term Salsus meaning salt. From ancient times to the present day the sausages mixture has been encased assuming a cylindrical form.

This shape has become traditionally the sausage shape, and in most instances, is one of the characteristics that differentiate sausages from other meat products (Kramlich et al., 1973).

2.1.2 Types

The term sausages cover such a large number of diversified products that no single system of classification is completely satisfactory. One system (Kramlich et al., 1973) separates sausages into two types:
1- Coarse-ground sausages, such as fresh pork sausages, semidry and dry sausages.
2- Emulsion-type products, such as frankfurters, bologna, and liver sausage.

Forrest et al. (1975) classified sausages into six categories depending on the processing methods:
1- Fresh sausages. e.g. fresh pork sausage.
2- Uncooked, smoked sausages. e.g. smoked pork sausage, mett-wurst, Italian pork sausage.
3- Cooked, smoked sausages. e.g. frankfurters, bologna, knackwurst, mortadella, berliner.
4- Cooked. e.g. liver sausage, Braunschweiger, bear salami, cooked salami.
5- Dry or fermented e.g. summer sausage, cervelat, dry salamis, Cappicola, pepperoni.
6- Cooked meat specialties. e.g. luncheon meat and loaves, sandwich spreads, jellied products.

2.2 Batter formulations:
2.2.1 Ingredients functionality.
2.2.1.1 Meat ingredients.
2.2.1.1.1 Meat.

In sausage processing careful selection of the meat for formulation is important in obtaining quality products. Whole carcass beef should contain no more than 10 – 12% fat, and plates, flanks, and shanks should be trimmed carefully and appear in the same ratio as in the carcass.

Trimmings should be free of bones, sinews, cords, and membranes. Beef trimmings may contain up to 25% trimmable fats (Kramlich et al., 1973).

Proteins originating from the meat ingredients (Table1) are responsible for water binding and fat emulsification. Variation in the ability of animal tissues to bind or emulsify fat in meat emulsions is due to:

1- The amount of soluble protein potentially available.
2- The emulsifying capacity of the protein. Cow meat is higher in emulsifying capacity than does pork cheek because it has less connective tissue and greater myofibrillar protein content (Forrest et al., 1975).
Table 1. Proximate compostion of meat.  
( In terms of 100 grams edible portion ).

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<thead>
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<th>Ingredients ( g )</th>
<th>Type of meat</th>
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<tr>
<td></td>
<td>Beef</td>
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<tr>
<td>Moisture</td>
<td>73.3</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0.0</td>
</tr>
<tr>
<td>Proteins</td>
<td>23.6</td>
</tr>
<tr>
<td>Fat</td>
<td>2.0</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>0.0</td>
</tr>
<tr>
<td>Ash</td>
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Source : Boutros ( 1986 )
Amyofibrillar protein matrix plays a decisive role in stabilizing bologna-type sausages (Katsaras and Peetz, 1994).

Moisture/protein ratios of various tissues provide some guide for the prediction of products final composition. Upon comparing the binding properties and moisture/protein ratio. It becomes apparent that meat with lower ratios generally performs better in sausage formulations (Forrest et al., 1975).

### 2.2.1.1.2 Fat

Fat is an important constituent of processed meat products. Fat content affect tenderness and juiciness of sausage (Forrest et al., 1975) and acts as a reservoir for flavour compounds and contribute to product texture (Bloukas and Paneras, 1996). Knowledge of fat content in meat ingredients is important, since meat inspection regulations limit fat content to maximum of 30% in cooked sausages (Forrest et al., 1975).

The mechanism(s) by which meat batter are stabilized include the emulsion theory which determine that fat is stabilized in the meat batter by the formation of an interfacial protein film (IPF) around the small fat globules which prevent their coalescence, and the other theory is physical entrapment theory which emphasizes the contribution of strong protein gel in holding the fat within the meat batter. i.e. fat is entrapped within the protein matrix (Barbut, 1995).

### 2.2.1.2 Non – meat ingredients

#### 2.2.1.2.1 Salt

Salt is a critical ingredient in the manufacture of many meat products. Apart from its role as a preservative (ILO, 1985), i.e. it
reduces the amount of water available for microbial growth (Forrest et al., 1975). Salt is important in the preparation of meat emulsion (ILO, 1985, Forrest et al., 1975) by solubilizing sarcoplasmic or myofibrillar proteins into aqueous phase so that they become available for coating fat particles (Forrest et al., 1975).

1.5% salt is a borderline salt level in frankfurters (Whiting, 1987), as determined by the amount of fat and water released during cooking. Increasing NaCl from 1.5 to 2.5% is associated with higher protein extractability and hence a reduction in liquid and fat losses during cooking. Monovalent salts such as potassium and lithium chloride formed stable meat batters, however the use of magnesium and calcium chloride resulted in an emulsion breakdown, because the divalent salts resulted in low protein extraction as it forms cross bridges among the protein which reduces their availability to emulsify fat (Barbut, 1995).

Salt is important in imparting recognizable product flavour (ILO, 1985), and it contribute to basic taste characteristics. (Kramlich et al., 1973).

### 2.2.1.2.2 Ice or water

Ice or water added to the meat mass provide considerable functional qualities. The ice or water chills the meat during the chopping or mixing operations, that permits longer and more efficient churning of the meat mass without mechanically over heating by lowering the initial temperatures and by lubricating the meat mass (Kramlich et al., 1973; ILO, 1985). Ice also reducing temperature during emulsification (Forrest et al., 1975).
Added water aids in dissolving sodium chloride and curing salts to give better distribution in the mass and impart, fluidity to the emulsion that aids in proper filling of the casings (Kramlich et al., 1973). The added water markedly affected texture and tenderness of the finished sausage (Kramlich, et al., 1973; Forrest et al., 1975; ILO, 1985).

Processed meat products must comply with federal meat inspection regulations with respect to moisture content, that moisture content of cooked sausage products must not exceed 4 times the meat protein content (by analysis) plus 10% (Forrest et al., 1975).

2.2.1.2.3 Sugar

Sugar is an ingredient to cure meat for preservation and development of unique colour, flavour, texture and platability properties (Forrest et al., 1975), and to mask the saltiness (Kramlich et al., 1973; ILO, 1985). In some cases sugar is used to bring about necessary chemical and microbial changes in the product (ILO, 1985), it provides a reservoir for an acid forming substance, so the proper pH of the sausage product is developed and maintained (Kramlich et al., 1973).

A variety of sugars, such as sucrose, corn syrup and solids, dextrose, and sugar derivatives such as sorbitol, are used (Kramlich et al., 1973), corn syrup and corn solids are only 40% as sweet as sucrose, and they are therefore often classified as fillers. Sucrose and dextrose are used primarily for their sweetening ability, and they readily available for fermentation by the lactic producing organisms used in preparing some dry sausage. The fermentation products are responsible for the characteristic flavours of these products (Forrest et al., 1975).
On sugars effects on water activity \( (a_w) \), (Elhardallou et al., 1980) proved that sucrose would have greater effect than dextrose in fermented sausage, this is due to the fact that the \( (a_w) \) is a molecular (not mass) phenomenon, and a given weight of disaccharide would have a greater effect than equal weight of polysaccharide. The term \( (a_w) \) has come to be generally used as a parameter for the stability of food. The shelf life and safety of foods is improved when their \( (a_w) \) is reduced because microorganisms that can cause spoilage or food poisoning are inhibited (Rodel et al., 1990).

The levels of sugar added are limited by regulation in some countries. Amounts in excess of 2.5% by product weight are recommend (ILO, 1985).

### 2.2.1.2.4 Spices and seasoning

Spices are aromatic substances of vegetable origin (Forrest et al., 1975; ILO, 1985).

Herbs are the dried leaves of plants (Forrest et al., 1975). Herbs and vegetables are used to season beef products to create distinctive flavour (Forrest et al., 1975; ILO, 1985). In addition to flavour seasonings contribute some what to the preservation of meat, certain spices possess antioxidant properties, and there by reduce the rate of oxidative rancidity development (Forrest et al., 1975). On the other hand, spices may carry excessively high bacterial loads (Forrest et al., 1975; Kramlich et al., 1973) that will shorten the shelf life of product (Forrest et al., 1975), so because of the collection and storage conditions to which they are subjected.

Some types of sterilization of natural spices is usually desirable.
(Kramlich et al., 1973). The meat industry is reported to be the biggest single user of spices, black pepper being the largest single item used. Others used include all spices as, basil, bay leaf, cardamon, cloves, ginger, mace, nutmeg, mustard, paprika, pimento, white pepper, caraway, coriander, celery seeds, cumin, marjoram, savory, sage, anise, cinnamon, onion, garlic, sesame, and fennel (Kramlich et al., 1973).

Either natural spices or the essential oils and oleoresins extracted from them may be used for flavouring sausages (Kramlich et al., 1973). Spice extracts have some advantages over ground spices as they are free of microbial contamination and are invisible in the finished meat product (Forrest et al., 1975), also soluble spices (essential and oleoresins), are low in anthocyanins and flavons, so it gives a brighter appearance to canned meat product whereas natural spices may darken when heated as a result of the presence of those compound (Kramlich et al., 1975).

### 2.2.1.2.5 Curing salts

In the general concepts of curing or preservation all the additives contribute to preservation. However specifically, the term "curing salt" refers to sodium or potassium nitrite and nitrate (Kramlich et al., 1973).

Since a high salt concentration promotes oxidation of myoglobin molecules, meat preserved by salting has unattractive gray colour (Forrest et al., 1975). The functions of nitrite in meat curing as determined by Kramlich et al. (1973) are:

1- To stabilize the colour of the lean tissues.
2- To contribute to the characteristic flavour of cured meat.

3- To inhibit growth of a number of food poisoning and spoilage micro–organisms that nitrite is effective in preventing the growth of Clostridium botulinum organism.

4- To retard development of rancidity.

The basic reaction occurring during colour development is represented by the following equations according to (Forrest et al., 1975)

\[
\text{Myoglobin} + \text{nitric oxide} \rightarrow \text{nitric oxide myoglobin} \\
\text{Nitric oxide myoglobin} \rightarrow \text{nitrosyl hemochrome}
\]

Nitrate serves principally as a source of nitrite

\[
\text{Nitrate} \xrightarrow{\text{nitrate reducing Organisms}} \text{Nitrite (Kramlich et al., 1973)}
\]

Nitrite is a toxic if consumed in excessive amounts. A single dose of nitrite in excess of 15-20 mg/kg of body weight may be lethal. The maximum level of nitrite now permitted in cured meat products is 20-40 times below this lethal dose (Forrest et al., 1975).

2.2.1.2.6 Alkaline phosphates

Phosphates cannot be added to sausages and other prepared meat products in the United States, but they are used extensively in these products in several European countries (Forrest et al., 1975). Only sodium acid pyrophosphate is permitted in sausages.

Phosphates increase the water holding capacity of meat and reduce the purge (Water and gelatin released from meat during cooking) (Forrest et al., 1975). Only alkaline phosphates are
effective for improving water binding since acid phosphates may lower the pH and cause greater shrinkage (Kramlich et al., 1973).

Legal limits for added residual phosphate are set at 0.5% in the finished product. Since meat contain 0.01% of natural phosphate, this must be subtracted in calculating the level added during curing (Kramlich et al., 1973).

2.2.1.2.7 Ascorbates and erythorbates

Ascorbates and erythorbates are interchangeably in sausage mix. They are active reducing agents that react with nitrite to give nitric oxide. These compounds ensure development of the desired colour in cured meats, and in this regard they have value.

Federal regulations permit addition of 0.75oz ascorbic acid or erythorbic acid (0.875oz sodium ascorbate erythorbate) per 100 lb sausage emulsion (kramlich et al., 1973).

2.2.2 Extenders, binders and fillers functionality on sausage quality

A variety of non-meat products have been used as fillers, binders and extenders in cooked comminuted meat products. They included in sausage formulations for one or more of the following reasons: (Forrest et al., 1973; Kramlich et al., 1975; Mittal and Usborne, 1985)

1- To improve emulsion stability.
2- To improve water binding capacity.
3- To enhance flavour.
4- To reduce shrinkage during cooking.
5- To improve slicing characteristics.
6- To reduce formulation costs.

Binders commonly used in sausage formulations are characterized as high protein content, and are either dried milk or soybean products. (Forrest et al., 1975).

Firmness in sausage product is dependent on the amount of lean meat in the formulation, whereas fat tends to soften the product and make it more tender. This tendering effect is also noted if excessive amount of isolated soy protein (ISP) are used. Advantages can be taken in the production of a high-protein, low-fat sausage product (Rakosky, 1970). Emulsifying properties correlated positively with protein and negatively with fiber contents. As ISP is rich in protein and poor in fiber contents, it showed good emulsifying capacity (Yasumatsu et al., 1972).

Non-fat dry milk (NFDM) provided optimum emulsion stability at the pH of meat (Mittal and Usborne, 1985), it provides lesser stability at higher pH. NFDM contains approximately 35% protein, of which 80% is casein and the remainder is largely B-lactoglobulin and lactalbumin. NFDM has limited ability to emulsity fat because the casein is combined with large amount of calcium, making it poorly soluble in water, and the protein must be solubilized in order to function as emulsifying agents. If sodium replace most of the calcium, water solubility and emulsification capacity of the casein is improved. This sodium replacement product is called calcium reduced NFDM (Forrest et al., 1975). A 3.5% incorporation of calcium-reduced NFDM in franks released more fat and moisture during cooking compared to all-meat product (Keeton et al., 1984). Lower yields were obtained from bologna as percentages of NFDM was increased (Rongey and Bratzler, 1966).
Dried whey, from which a part of the lactose has been removed, may have a higher emulsifying capacity than NFDM, since casien is not present and B-lactoglobulin and lactalbumin are readily soluble protein (Forrest et al., 1975).

The defatted corn germ protein (CGP) (Zayas and Lin, 1988) added at a level of 3%, significantly increased water retention and yield of finished products. Shear force and firmness decreased with addition of defatted CGP. Textures of frankfurters containing defatted CGP was softer, there were no significant differences in the juiciness of the finished products of frankfurters containing CGP and the control. Sensory properties (colour, texture, aroma, flavour, overall off-flavour acceptability) of frankfurters with defatted CGP and control samples were in the acceptable range.

Wheat germ protein flour (WGPF), corn germ protein flour (CGPF), and soy flour (SF) were used as additives at a level of 3.5% in comminuted meat products (Gnanasambandam and Zayas, 1992), they improved the batter characteristics by increasing water holding capacity (WHC) and batter stability and decreasing cooking loss. The viscosity and adhesiveness of batters containing protein additives should increase when compared to the control samples (all meat). Products containing WGPF and SF were firmer than either those containing CGPF or the control having the same level of added water. Colour, aroma, and flavour of frankfurters were influenced by protein additive. Addition of WGPF had improved batter and product characteristics comparable to other accepted non-meat protein additives, such as SF and CGPF. WGPF is a potential source of non-meat protein for frankfurters and bologna.

The use of Lupin seed protein isolate (LSPI) from seeds of lupinus albus ssp. as powder ingredient for the manufacture of frankfurters at
level up to 2% of the formulation weight (Alamanou et al., 1996) improves the processing yield, reduces the purge-accumulation in the packaged product during the refrigerated storage and does not affect, negatively, the colour, the texture and the sensory characteristics of the finished product. However, it can not be used at higher levels because, although it increases significantly the processing yield and reduces the purge accumulation it affects negatively the overall acceptability of the product due to an unpleasant and rather bitter taste.

In the use of lablab and cowpea flour as binders with high protein content (Table 2 and Table 3) to substitute 5% level of meat in weiner type sausage products (Elkhalifa et al., 1997), demonstrated that both improved batter characteristics by increasing level of protein, pH and decreasing jelly separation. Lablab flour (LF) and cowpea flour (CF) reduced purge accumulation during the refrigerated storage and did not affect, negatively, processing yield and colour characteristics of the finished products.

In comparison to control, addition of LF or CF increased 2nd bite hardness while not affecting cohesiveness, guminess, and chewiness of the finished products. Sensory properties of weiner with LF or CF were in the acceptable range whereas products with CF had the lowest scores.

The work carried by (Bloukas and Paneras, 1996) on the use of potato starch, finely ground toasted bread, and rice bran at a level of 3.0% in the production of low-fat frankfurters (10% fat, 13% protein) explained that finely ground toasted bread can be used as a fat substitute in the production of low-fat frankfurters. In comparison to potato starch, which is commonly used in the production of frankfurters, it improves the colour, texture, and the sensory properties while not affecting the processing yield.
Table 2. Proximate composition of lablab bean flour. 
( % dry basis ).

<table>
<thead>
<tr>
<th>Component</th>
<th>Whole lablab flour</th>
<th>Peeled lablab flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>5.2 ± 0.03</td>
<td>6.7 ± 0.25</td>
</tr>
<tr>
<td>Crude protein</td>
<td>28.1 ± 0.02</td>
<td>28.9 ± 0.59</td>
</tr>
<tr>
<td>Crude fat</td>
<td>1.7 ± 0.6</td>
<td>1.3 ± 0.16</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>7.5 ± 1.73</td>
<td>1.1 ± 0.46</td>
</tr>
<tr>
<td>Total Ash</td>
<td>3.7 ± 0.08</td>
<td>3.8 ± 0.06</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>53.8 ± 0.49</td>
<td>58.2 ± 0.3</td>
</tr>
</tbody>
</table>

Source : Melaku (1998 )
Table 3. Proximate composition of raw cowpea.
(In terms of 100 grams edible portion).

<table>
<thead>
<tr>
<th>Component</th>
<th>g/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>8.2</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>54.8</td>
</tr>
<tr>
<td>Proteins</td>
<td>26.1</td>
</tr>
<tr>
<td>Fat</td>
<td>2.6</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>4.4</td>
</tr>
<tr>
<td>Ash</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Source: Boutros (1986)
The use of commercially produced finely ground rice bran in the production of low-fat frankfurters, is questionable. Although in comparison to starch, it improves the skin strength of franks, it negatively affects the flavour and overall acceptability of the product.

An English type fresh skinless sausage in which some of the meat (mutton, pork or beef) was replaced on a protein to protein basis by chickpea flour processed by Verma et al. (1984) showed that the acceptability of mutton sausages containing chickpea flour was not affected at levels of substitution up to 40% whereas pork and beef sausages were significantly less acceptable at substitution levels above 30%.

In all sausages the incorporation of chickpea flour led to increased cooking losses and softer textures and caused discolouration of the raw sausages which become more prominent during storage at 0 °C for 7 days. The undesirable surface colour was typical to metmyoglobin colour. Met-myoglobin formation in sausage containing up to 30% chickpea flour may be due to the presence of lipoxidase in chickpea flour, which oxidizes the unsaturated fats present to peroxides or related compounds which then catalyze myoglobin oxidation.

The use of sunflower flour (Wills and Kabirullah, 1981) as a substitute ingredient for wheat gluten in the type of butcher sausage produced in Australia resulted in a sausage that was equally acceptable to the sensory panel, produced a more stable sensory emulsion mix and was not inferior in any cooking parameter to the gluten sausage.

Comparison with the sausage prepared with soy protein isolate showed that the sunflower flour sausages mix had a greater stability but both were equally acceptable to the taste panel. The presence of green oxidation products of chlorogenic acid is a potential problem in the use of sunflower protein in foods (Sabir et al., 1974) but the sensory
evaluation panels did not find that the levels of colour present in sausages prepared with sunflower flour significantly affected the colour of either the uncooked or the cooked sausage. However, the colour of sausage produced with sunflower protein isolate was significantly darker and dislike by the taste panels although it was obviously not considered as important as flavour or texture as scores for the overall acceptability of sausage prepared with sunflower protein isolate were not significantly different to those of sunflower flour.

Fillers which are high in starch content but relatively low in protein such as potatoes (Table 4) were able to bind large amounts of water but were poor in emulsification ability (Forrest et al., 1975). The amount of extenders permissible in sausage is specified by meat inspection regulations.

Soy products (with the exception of isolated soy protein), cereal flours and starches and NFDM or calcium-reduced NFDM may be added to cooked sausage, either singly or in combination, to a maximum of 3.5% by weight of the finished product. Isolated soy-protein may account for no more than 2% of the sausages. Sausages containing more extenders than these limits must be labeled as "imitation" (Forrest et al., 1975).

2.3 Sausages casing

Casings determine sausages size and shapes, and serves as processing molds, a containers during handling and shipping, and as merchandizing units for display. Casings must not only be able to withstand the forces produced during stuffing but also the forces of linking or closure. (Kramlich et al., 1973).

Two types of casings as reported by Forrest et al. (1975) and ILO (1985) are in general use:
Table 4:

Proximate composition of potatoes.
(In terms of 100 grams edible portion).

<table>
<thead>
<tr>
<th>Component (g)</th>
<th>Peeled raw potatoes</th>
<th>Cooked mashed potatoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>76.0</td>
<td>78.6</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>21.0</td>
<td>16.1</td>
</tr>
<tr>
<td>Proteins</td>
<td>1.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Fat</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Ash</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Source: Boutros (1986)
1- Natural casings: which are derived from the gastro-intestinal tracts of swine, cattle, and sheep

2- Manufactured casing:
Forrest et al. (1975) classified the manufactured casings into four classes:
1- Cellulose casing which are manufactured in size ranging from 1-5 centimeter in diameter, for small sausages, up to 15 centimeter for large sausages such as bologna.
2- Inedible collagen casings which are regenerated from collagen extracted from skin and hides they must be removed prior to consumption of the product, as must cellulose casings.
3- Edible collagen casings which are used largely for fresh pork sausages and frankfurters.
4- Plastic tubes or bags which are used as sausages containers in certain application. They are impermeable to smoke and moisture there- for they are used for products which are not smoked, such as fresh pork sausage or liver sausage, or with products which are heat processed in hot water.

2.4 Sausages manufacture

2.4.1 Comminution
The process by which particle size is reduced for incorporation of meat into sausage type products. The degree of comminution differs greatly between various processed products, (Forrest et al., 1975).

Two main advantages as compiled by Forrest et al. (1975) are gained from all comminution processes:
1- Improved uniformity of products due to more uniform particle size and distribution of ingredients.
2- Increase the tenderness as the meat is subdivided into smaller particles.

2.4.2 Mixing

Kramlich et al. (1973) reported that, cylinders of fat and lean obtained by grinding are tumbled in a mixer to give a uniform distribution of fat and lean particles with suitable additions of required ingredients to obtain the desired texture and uniformity of composition.

2.4.3 Chopping

In a cutter or bowl chopper, comminution and mixing of the meat ingredients are accomplished by revolving the meat in a bowl past a series of knives mounted on a fixed shaft that rotate at high speed (ILO, 1985). Speed of the knife, rpm of the bowl, and sharpness of the blade are all factors in its performance (Kramlich et al., 1973).

2.4.4 Emulsifying

An emulsifier combines the principles of grinding and chopping (Kramlich et al., 1973). The emulsifier should be fed uniform mixes because it rapidly passes increments of meat mixer through an orifice that may hold 2 lb or less of product.

In a few second, 100 lb of meat pass through an emulsifier, with a rise in temperature of 8-15°F (Kramlich et al., 1973; Forrest, et al., 1975).

Some warming is beneficial that it helps to release soluble protein, accelerates cured colour development and improves flow characteristics. However if the temperature become too high during emulsification, emulsion breakdown can occur during subsequent heat processing (Forrest et al., 1975).
The advantages in the use of emulsifier has been the speed of handling materials, the high degree of disintegration of meat tissues and the ease of obtaining desired textures (Kramlich et al., 1973).

### 2.4.5 Stuffing

Sausage batter is transferred to stuffers for extruding the mix or emulsion into casings. At this point, the size and shape of the product is determined (Kramlich et al., 1973).

### 2.4.6 Linking and tying

The encased mass is tied with thread or fastened with metal clips. For frankfurters and other small sausages, hand linking is rarely done today. Machines that stuffed and link are now the accepted practice (Kramlich et al., 1973).

Large sausage item are tied or clipped at one end with a hanging tie and suspended from a smoke stick or hook so the entire surface is free from contact with the equipment, this permits a good flow of air around the sausage in the smoke house (Kramlich et al., 1973).
3- MATERIALS AND METHODS

3-1 Materials

Fresh beef meat was purchased from local butcher at Wad Medani. Meat from the same carcass was used for all treatments to minimize variation from the meat source. Fat that was to adjust the desired fat level of the sausage was obtained from beef trim.

Lablab bean (Dolichos lablab L.) seeds of brown coloured seed coat were bought from the local market at Wad Medani. Unpeeled lablab flour (UPLF) was prepared from sound seeds which were cleaned and dried then ground to pass through 425 µm sieve using a laboratory type hammer mill. Peeled lablab flour (PLF) was prepared from cleaned seeds which were soaked overnight and decoated manually by hand peeling and dried, then pulverized in a laboratory hammer mill to an average particle size of 425 µm.

Potato was bought from the local market at Wad Medani, blanched and dried then ground to pass through 425 µm sieve using a laboratory type hammer mill to produce potato flour (PF). PF stored in stoppered glass bottles at room temperature until used.

3.2 Methods

3.2.1 Autoclaving

The samples to be autoclaved were first ground in the raw form to 425 µm size. The flours were spread in trays. The trays were covered with foil and then autoclaved (121°C, 15 lb for 20 min). The autoclaved samples were air dried over night at room temperature. The autoclaved
flour samples (UPLF and PLF) were stored in stoppered glass bottles at room temperature until used.

### 3.2.2 Manufacture of the sausage

The commercial formulation of sausage was 70% lean beef, 10% trim fat, 10% water as crushed ice, 8% potato flour, 2% powder milk, 1.5% salt, 0.3% pepper, 0.3% sugar, 0.15% nutmeg and 0.15% cinnamon, the autoclaved UPLF or PLF were used to replace PF. The meat and fat were ground through a 5-mm plate and transferred to a bowl cutter. The other ingredient, were added and the mixture was chopped for 5 min.

A sufficient amount of meat batter was removed for analysis of pH, batter composition and jelly and fat separation.

The majority of the batter was stuffed into sheep casings and linked at lengths of about 6-7 cm (Fig.1).

Part of the sausage batter was packed in moisture-proof plastic bags and stored for 7 days at 10 °C for further testing. All experiments were repeated four times.

### 3.2.3 Raw batter analysis

#### 3.2.3.1 pH measurement

A 20g of batter were homogenized using a laboratory mixer emulsifier with 80 ml distilled water for 60 sec. The pH of the homogenized sample was measured using a pH-meter.

#### 3.2.3.2 Proximate composition

Analysis of proximate composition was carried out on batter with autoclaved UPLF, autoclaved PLF and with PF. The proximate compositions determined include moisture, ash, protein and fat content. Results were reported on wet basis.
Fig. 1. Sausages containing three different binders (PF, PLF, UPLF)

A = Sausages containing potato flour (PF)
B = Sausages containing autoclaved peeled lablab bean flour (PLF)
C = Sausages containing autoclaved unpeeled lablab bean flour (UPLF)
3.2.3.2.1 Moisture content

The standard methods of the Association of Official Analytical Chemists (AOAC, 1984) was used to determine the moisture content of the samples in the present work. The samples were weighed into a pre-dried, weighed and clean porcelain dish.

The samples were placed in an air-oven and dried at 130°C for 3 hours. Finally, samples were removed from the oven, cooled in a desiccator at room temperature and weighed. Moisture content of the samples was then calculated as follows:

\[
\text{Moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100
\]

3.2.3.2.2 Protein content

Protein contents of the samples analyzed were determined according to A.A.C.C (1983) method in which one gram sample was digested by heating with concentrated sulphuric acid for 2½ hours in the presence of copper sulphate and potassium sulphate as digestion mixtures. After cooling the digest was diluted to a volume of 100 ml with distilled water. Then, 5ml of the diluted digest was transferred to a clean steam distillation unit and 10ml of 40% NaOH solution poured into the distillation flask. The ammonia was distilled into a receiver flask containing boric acid solution. The ammonia trapped in boric acid solution was titrated directly with a standard 0.1 N HCl solution using (methyl red + Bromocressol green) double indicator. The change in colour of the mixture from blue to pink was taken as the end point.

The nitrogen content of the samples was calculated using the following expression.
ml of HCL \hspace{1cm} \text{Normality} \hspace{1cm} \text{volume made up}

\[ N\% = \frac{\text{Used in titration}}{\text{ml of HCL}} \times \frac{\text{of HCL}}{\text{x of the digest}} \times 14 \times \frac{\text{of the digest}}{1000} \times \frac{\text{weight of}}{\text{the sample taken}} \times 1000 \]

The protein value was computed from the nitrogen content multiplied by a conversion factor (6.25), i.e., \( \% \text{ crude protein} = \% N \times 6.25 \).

### 3.2.3.2.3 Fat content

Crude fat was determined according to the method of the American Oil Chemists Society (AOCS, 1981). 3-4 grams of sample were weighed into a filter paper and wrapped in such a fashion as to prevent escape of the meat. The wrapped sample was put into a thimble and a piece of absorbent cotton was placed in the top of the thimble to distribute the solvent as it drops on the sample. The thimble containing the sample was then placed in a soxhlet extraction tube, and attached to a pre-weighed extraction flask containing 150ml of n-hexane.

The extraction flask was disconnected after 6 hours extraction period and then the hexane was recovered by distillation. Last traces of the solvent were removed by putting the flask in an air-oven.

The flask containing the crude oil was cooled in a dessiccatator at room temperature and weighed. The crude fat content was calculated as follows:

\[
\text{Crude fat } \% = \frac{\text{Weight of oil extracted}}{\text{Weight of sample}} \times 100
\]
3.2.3.2.4 Ash content

The method of AOAC (1984) was used to determine the ash content of the samples analyzed in this study. 2-3 grams of samples were weighed into a clean pre-dried and weighed porcelain dish. The dish containing the sample was placed in a muffle furnace at 550°C and left for 5 hours at this temperature.

Then, the dish with its content was weighed again after cooling in a desiccator to room temperature. Ash content was calculated as follows:

\[
\text{% Ash} = \frac{\text{Weight gain by the dish}}{\text{weight of the sample}} \times 100
\]

3.2.3.3 Batter Stability

The batter stability was determined by the procedure of Bloukas and Honikel (1992). At the end of comminution process three pre-weighed cans were filled with 200g batter. The cans were closed and heated for 1 hour in an autoclave at 121°C. After cooling in running tap water the cans were stored at 4°C for 24hrs. After warming up the cans in a water bath at 45°C for 1 hour, they were opened. Then, the fluid of jelly and fat were separated in each can and collected in a 50ml volumetric cylinder. The fluids were measured in ml and calculated as a percentage of the original weight of the batter, the mean value of the three cans was taken for each treatment.
3.2.4 Product analysis

3.2.4.1 Cooking Loss and cooking yield

Cooking losses were determined by weighing ten pieces of product from each treatment and cooking them in a steam cooker at 75°C for 15 min. After cooking the products were cooled to room temperature.

The cooking loss and cooking yield were calculated according to the following equations.

\[
\text{Cooking loss} \% = \left( \frac{\text{Total weight loss}}{\text{Raw weight}} \right) \times 100
\]

\[
\text{Cooking yield} \% = \left( \frac{\text{Cooked weight}}{\text{Raw weight}} \right) \times 100
\]

3.2.4.2 Purge accumulation

Purge was defined as water and gelatin released from meat during cooking (Forrest et al., 1975). Two vacuum packages (about 250 - 300g) per treatment were used to determine purge accumulation of sausages batter after 7 days of storage at 2°C. Before packing, each link of sausage was dried with paper towels and all links per package were weighed. At the end of the storage period the sausages were removed from the package and each link was again dried with paper towels and all the links per package were re-weighed. Purge accumulation was calculated as the total weight loss x 100 divided by the initial weight.

3.2.4.3 Sensory evaluation

To assess the eating quality, the sausages were shallow fried in vegetable oil for 5 min and served hot to a panel of nine judges. Samples of each treatment were randomly presented to each judge. The judges were asked to evaluate quality in terms of texture, flavour, visual colour.
and appearance and over all acceptability on a 9 point scale (9 = like extremely, 1 = dislike extremely).

3.2.4.4 **Statistical analysis**

Statistical analysis was performed using MSTAT (1985) program. All parameters studied were analyzed by two-way analysis of variance. Means were compared by using LSD test with significance level 0.05.
4. RESULTS AND DISCUSSION

4.1 Batter analysis

4.1.1 pH

Mean values for pH of batters are given in Table 5. The control samples containing potato flour (PF) had lower (P < 0.05) pH than the treatments with autoclaved, unpeeled lablab flour (UPLF) and/or peeled lablab flour (PLF), this result was in agreement with those of Alamanou et al. (1996), who found that the addition of Lupin seed protein isolate (LSPI) at level of 3% to frankfurters had significantly increased (P< 0.05) batter pH to control treatment (0 level of LSPI), as both Lupin seed and lablab bean were legumes. Lablab could be considered as a unique protein sources for human consumption because of their high biological and nutritional values (Askar et al., 1982). The increasing pH values by adding defatted soy flour (DSF), (Yetim et al., 1992) to the meat products is usually a desirable aspect in order to obtain a stable sausage emulsion and to increase the water binding and emulsion capacity of meat in this type of product. The lower pH affected the extractability of salt soluble proteins with the result that the emulsion capacity was lower and the emulsion stability and yield of product were poor (Anjaneyulu et al., 1991).

4.1.2 Proximate composition

As shown in Table 5, no significant difference (P > 0.05) in moisture, ash and fat content among the samples. This has been suggested to be related to that, there is a little difference between peeled raw potatoes and unpeeled lablab flour in fat and ash content. The fat and ash content in raw peeled potatoes were (0.0 & 0.8), respectively.
Table 5. Batter pH and Proximate composition a.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>pH</th>
<th>Moisture %</th>
<th>Ash %</th>
<th>Protein %</th>
<th>Fat %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batter containing PF</td>
<td>5.63&lt;sup&gt;B&lt;/sup&gt;</td>
<td>55.82&lt;sup&gt;A&lt;/sup&gt;</td>
<td>2.56&lt;sup&gt;A&lt;/sup&gt;</td>
<td>8.10&lt;sup&gt;B&lt;/sup&gt;</td>
<td>11.97&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Batter containing UPLF</td>
<td>6.23&lt;sup&gt;A&lt;/sup&gt;</td>
<td>57.53&lt;sup&gt;A&lt;/sup&gt;</td>
<td>2.50&lt;sup&gt;A&lt;/sup&gt;</td>
<td>11.81&lt;sup&gt;A&lt;/sup&gt;</td>
<td>14.53&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Batter containing PLF</td>
<td>6.21&lt;sup&gt;A&lt;/sup&gt;</td>
<td>58.63&lt;sup&gt;A&lt;/sup&gt;</td>
<td>2.51&lt;sup&gt;A&lt;/sup&gt;</td>
<td>13.56&lt;sup&gt;A&lt;/sup&gt;</td>
<td>11.82&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

PF = potato flour.
UPLF = unpeeled lablab flour.
PLF = peeled lablab flour.
A, B = Means within same column with different superscripts are different (P < 0.05).
a = the values are average of four determinations.
and in unpeeled lablab flour were (1.7 & 3.7) respectively (Table 2). The level of ash in raw potatoes may increase after drying.

Melaku, (1998) approved that the process of dehulling of lablab bean reduced only the crude fiber level and enhanced the carbohydrate content which support the above result of this study.

There were no significant differences (P > 0.05) in protein of UPLF and PLF batter mixes, this is in agreement with Melaku, (1998) who found that there was a little difference in protein content of whole lablab bean flour and peeled lablab bean flour. The difference was significant (P < 0.05) in protein of treated samples and control samples, as high protein content is a distinguishing feature of legume seeds.

4.1.3 Batter Stability

Jelly separation for treated samples containing UPLF and/or PLF on 0- day was higher ( P < 0.05 ) than control containing PF, this result could be attributed to that, potatoes are high in starch content but relatively low in protein ( Table 4 ), so they were able to bind large amount of water but are poor in emulsification ability ( Forrest et al., 1975 ). This fact support the result shown in Table 6 , that fat separation at 0 - day and 7 - day storage for treated samples was less ( P < 0.05 ) than control samples. The fat separation at 0 - day and 7 - day storage in sample containing UPLF was higher ( P < 0.05 ) than in samples containing PLF, this means that emulsifying properties correlated positively with protein and negatively with fiber content ( Yasumatsu et al., 1972; Mittal and Usborne, 1985 ), as UPLF batters were lower in protein content (Table 5) and high in fiber content because UPLF had higher fiber content than PLF (Table 2). There were no significant differences ( P > 0.05) in jelly separation at 7 - days storage (Table 6) between the control samples and treated samples containing PLF, this
Table 6. Jelly and fat separation\textsuperscript{a}

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Jelly separation</th>
<th>Fat separation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - day</td>
<td>7 - day</td>
</tr>
<tr>
<td>Batter containing PF</td>
<td>0.67\textsuperscript{B}</td>
<td>1.33\textsuperscript{B}</td>
</tr>
<tr>
<td>Batter containing UPLF</td>
<td>7.17\textsuperscript{A}</td>
<td>5.14\textsuperscript{A}</td>
</tr>
<tr>
<td>Batter containing PLF</td>
<td>6.5\textsuperscript{A}</td>
<td>0.75\textsuperscript{B}</td>
</tr>
</tbody>
</table>

PF = Potato flour
UPLF = Unpeeled lablab flour
PLF = Peeled lablab flour
A, B, C = Means with in same column with different superscripts are different (\(P < 0.05\))
a = Means of triplicate samples
had been suggested to be attributed to the fact that, improved functional properties and maximum protein extraction occur when salt has time to infuse into the muscle tissue (Acton and saffle, 1969; shannon, 1978; Okerman and Crespo, 1982). The result attributed to the absorption of PLF during refrigerated storage to the excessive water added during preparation of batter. While the UPLF did not reduce the jelly separation during the storage period.

4.2 Product analysis

4.2.1 Cooking loss and cooking yield

Cooking yields were determined as the percent solid remaining after cooking. Low processing yields usually result from low stability of the sausage emulsion.

Incorporation of UPLF and/or PLF in sausage formulations give lower (P < 0.05) processing yield than those containing PF (Table 7), and higher (P < 0.05) cooking loss at 0-day storage. This support the fact of, as a consequence of an increase in water holding capacity (WHC) the cooking loss of meat dropped significantly (Anjaneyuln et al., 1991), but as batters containing UPLF and/or PLF are high in protein content (Tables 5) than batter containing PF, they had high emulsifying properties (Yasumatsu et al., 1972; Mittal and Usborne , 1985 ), which increase processing yield respectively (Townsend et al., 1968; Barbut, 1995). This means the processing yield of product was not affected negatively by addition of autoclaved UPLF and/or PLF, but at high temperatures more starch is gelatinized ( starch granules swell in water during cooking ) giving a better developed gel network which can hold large amount of water in sausages containing PF ( Bloukas and Paneras, 1996 ).
Table 7. Cooking loss, cooking yield, and purge-accumulation\(^a\).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cooking loss</th>
<th>Cooking yield</th>
<th>Purge accumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sausage containing PF</td>
<td>14.68(^c)</td>
<td>85.23(^A)</td>
<td>1.95(^A)</td>
</tr>
<tr>
<td>Sausage containing UPLF</td>
<td>27.91(^A)</td>
<td>72.09(^c)</td>
<td>1.63(^B)</td>
</tr>
<tr>
<td>Sausage containing PLF</td>
<td>21.30(^B)</td>
<td>78.71(^B)</td>
<td>1.14(^c)</td>
</tr>
</tbody>
</table>

PF = potato flour.
UPLF = unpeeled lablab flour.
PLF = peeled lablab flour.
A, B, C = Means within same column with different superscripts are different (P < 0.05).
a = The values are average of four determinations.
4.2.2 Purge accumulation

The results of purge accumulation are presented in Table 7. The treated samples had less (P < 0.05) purge accumulation during the seven days of refrigerated storage at 2°C than the control samples. This result was correlated to the result which shows the jelly separation of treated samples at 7-days storage was decreased.

Processing yield and purge accumulation found to be significantly correlated with the batter pH and product pH respectively (Alamanou et al., 1996), who found that the addition of Lupin seed protein isolate (LSPI) significantly decreased the purge accumulation of frankfurters during the 1st week of refrigerated (4°C) storage.

Processing yield, purge accumulation, jelly and fat separation are indicative of emulsion stability, which represent the ability of meat emulsion to retain moisture and fat upon further processing (Townsend, 1968; Barbut, 1995).

4.2.3 Sensory evaluation

According to Gnanasambandam and Zayas (1992) aroma and flavour are probably the most important attributes that influence the sensory properties of comminuted meat products extended with non-meat protein additives.

The data on sensory quality of the cooked sausages, in terms of appearance, texture, flavour and overall acceptability are presented in Table 8. There were no significant difference (P > 0.05) in appearance, texture and flavour among treated and control samples. This means that autoclave treatment mask the beany flavour of PLF and UPLF, as lablab bean is not used widely in human foods due to its repellent beany flavour (NAS, 1979).
However, sausage containing UPLF were significantly different (P < 0.05) in overall acceptability than those containing PLF, the main reason may be due to the presence of slight beany flavour as a result of lablab bean peel, so the samples containing UPLF received lower scores in overall sensory evaluation (Table 8).
Table 8. Sensory evaluation of sausages

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Texture</th>
<th>Appearance</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sausage containing PF</td>
<td>7.00 ^A</td>
<td>7.78 ^A</td>
<td>7.00 ^A</td>
<td>7.22 ^AB</td>
</tr>
<tr>
<td>Sausage containing UPLF</td>
<td>6.89 ^A</td>
<td>6.44 ^A</td>
<td>6.78 ^A</td>
<td>6.56 ^B</td>
</tr>
<tr>
<td>Sausage containing PLF</td>
<td>7.56 ^A</td>
<td>7.22 ^A</td>
<td>7.44 ^A</td>
<td>7.67 ^A</td>
</tr>
</tbody>
</table>

PF = potato flour
UPLF = unpeeled lablab flour
PLF = peeled lablab flour
A, B = Means with in same column with different superscripts are different (P < 0.05).
5. CONCLUSIONS AND RECOMMENDATIONS

Substitution of potato flour (PF) with autoclaved unpeeled lablab flour (UPLF) or/and peeled lablab flour (PLF) at 8% level, improved batter characteristics by increasing level of protein, pH, reduced fat separation at 0-day and 7-day of storage, reduced purge accumulation, and did not affect negatively jelly separation, cooking yield, and sensory characteristics of colour, texture, flavour, and overall acceptability of the finished product.

It is clear that fat separation of the batter was influenced by protein content of batter, it decreased as protein content of batter increased, which reflected the importance of protein to retain fat in the product, contributing to better quality characteristics of the finished product. Therefore, this research study has proved the possibility of using autoclaved UPLF and PLF as important emulsifier in many food systems as in emulsified sausages.

In the preparation of batter the meat should be chopped with ice and salt first then held at 0 – 4 °C for up to 12 hours before emulsification ( before addition of ground fat trim ), thereby allowing more efficient protein extraction and this may reduce the percentage of jelly separated from the batter. Further research is needed to study the suitability of protein concentrates and isolates of lablab as potential source of non-meat protein in comminuted meat products.
REFERENCES


MSTAT (1985) Michigan State University. East Lansing, M I, USA.


Appendix 1

Components of equipment used in sausages manufacture as compiled by Kramlich et al. (1973).
QUESTIONNAIRE FOR HEDONIC SCALE

NAME : ……………….. DATE : ………………..
PRODUCT : …………….. SAMPLE NO : ……..

We appreciate your cooperation and assistance. We expect to rate or to judge samples to be tested under the following scale:

- 9 : like extremely
- 8 : like very much
- 7 : like moderately
- 6 : like slightly
- 5 : neither like nor dislike
- 4 : dislike slightly
- 3 : dislike moderately
- 2 : dislike very much
- 1 : dislike extremely

Please make cross mark (x) in the box you believe your judging is more suitable.

### A: Visual color and appearance:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
</table>

### B: Flavour (taste and odor):

<table>
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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
</table>

### C: Texture:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
</table>

### D: Overall acceptance level

<table>
<thead>
<tr>
<th>1</th>
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<th>6</th>
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</tr>
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</table>

Comment:

………………………………………………………………………………………………………………
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