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Temporal Dominance of Sensations of peanuts and peanut products in relation to Hutchings and Lillford's "breakdown path"

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ABSTRACT

Hutchings and Lillford (Journal of Texture Studies, 19, 103–115, 1988) proposed a "breakdown path" whereby particle size reduction occurs through mastication in conjunction with the secretion of saliva to form a swallowable bolus. The swallowing trajectory of whole peanuts, peanut meal and peanut paste were studied with the Temporal Dominance of Sensations technique. The sensations for whole peanuts progressed from hard, to crunchy, to chewy, to soft and ended compacted on teeth. Predictably peanut meal missed out the first two sensations, progressing from chewy, to soft and ending compacted on teeth. However peanut paste, which starts as a soft suspension with relatively little structure appears to thicken and stick to the palate during oral processing. We propose that the "hard to swallow" sensation elicited by peanut paste may be due to water absorption from the saliva as they mix in the mouth.

1. Introduction

1.1. Texture of peanuts & their products

The peanut is the seeds of the legume *Arachis hypogaea*. Peanuts have a tradition of use as a snack food and are frequently processed in a variety of ways such as roasting and grinding to produce a range of products which are eaten in a variety of ways such as roasted salted snacks, sate sauce, peanut butter, etc. Table 1 shows the proximate composition of various peanut products, revealing that they are a good source of protein, carbohydrate and fat, making them highly nutritious and a good source of energy. The low water content also helps to provide a long shelf life, limited only by the potential for fat oxidation.

As a popular and widely available food, peanuts (and their products) have been the subject of sensory evaluation studies. Using descriptive analysis, Gills and Resurreccion (2000) identified eight oral textural attributes for peanut butter, being the stickiness and graininess when first introduced to the mouth (prior to mastication), the hardness of the first bite as well as the adhesiveness, gumminess during mastication and residual sensations of: oiliness, mouthcoating and mouthdryness. Other researchers have studied oral food processing (mastication, bolus formation, swallowing, etc.), for example electromyography has been used to study the muscle activity while chewing peanuts (Hanawa, Tsuboi, Watanabe, & Sasaki, 2008; Kohyama & Mioche, 2004; Kohyama, Mioche, & Martin, 2002) and the resultant particle size distribution evaluated by various techniques such as wet sieving or laser diffraction (Peyron, Mishellany, & Woda, 2004). Flynn et al. looked at particle size distribution of peanuts prior to swallowing and postulated multiple compartments within the mouth during mastication (Flynn et al., 2011). While most researchers looked at single foods, Hutchings and colleagues embedded peanuts in gel matrices to investigate the particle break down dynamics (Hutchings et al., 2011; Hutchings et al., 2012). Several authors have looked at the importance of fluid and specifically saliva on bolus formation and swallowing of peanuts (Pereira, de Wijk, Gaviao, & van der Bilt, 2006; Pereira, Gaviao, Engelen, & Van der Bilt, 2007; van der Bilt, Engelen, Abbink, & Pereira, 2007). Hiiemae et al. investigated bolus formation and its movement in the mouth for several foods including peanuts (Hiiemae, 2004; Hiiemae & Palmer, 1999). Once comminuted by the teeth, and formed into a bolus, the swallowing threshold for peanuts has been determined (Engelen, Fontijn-Tekamp, & van der Bilt, 2005).

Despite having been incorporated into a wide range of foods whose physical properties have been studied, whole peanuts and peanut meal have not themselves been characterized from a rheological point of view. Having said this, peanut butter is a viscous oily paste. Rheological studies on the flow behavior of peanut

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Table 1
Percentage composition of peanut products based on McCance & Widdowson's the composition of foods integrated data set (Food Standards Agency., 2002).

	Water	Protein	Carbohydrate	Fat
Plain peanuts	6.3	25.8	12.5	46.0
Dry roasted	1.8	25.7	10.3	49.8
Roasted salted	1.9	24.7	7.1	53.0
Wholegrain peanut butter (peanuts, oil & salt only)	0.7	24.9	7.7	53.1
Peanut butter (smooth)	1.1	22.8	13.1	51.8

butter show that it is actually shear thinning with a yield stress (i.e. plastic behavior) (Citerne, Carreau, & Moan, 2001; De Man, 1990; Shakerardekani, Karim, Ghazali, & Chin, 2013).

1.2. Temporal Dominance of Sensation

The Temporal Dominance of Sensations (TDS) technique follows the oral breakdown trajectory of food from the assessors first bite to the point of clearance from the mouth. Throughout the process the assessor identifies the dominant sensation that are perceived and by comparing responses between the panel we are able to recognize patterns for particular foods by the group of subjects under test. TDS has been applied to a variety of liquid foods and drinks such as water (Teillet, Schlich, Urbano, Cordelle, & Guichard, 2010), espresso coffee (Barron et al., 2012), blackcurrant squash (Ng et al., 2012) wine (Meillon, Urbano, & Schlich, 2009; Sokolowsky & Fischer, 2012) and olive oil (Dinnella, Masi, Zoboli, & Monteleone, 2012). It has also been used to examine semi solid foods like yoghurt (Bruzzone, Ares, & Gimenez, 2013) and salmon-sauce combinations (Paulsen, Næs, Ueland, Rukke, & Hersleth, 2013). TDS is ideal to follow the breakdown of foods in the mouth using solid products including breakfast cereals (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009; Meyners, 2011; Sudre, Pineau, Loret, & Martin, 2012) and fish fingers (Albert, Salvador, Schlich, & Fiszman, 2012). In some cases it is changes in texture which are being measured, while in other situations the researchers are interested in flavor release of tastants such as salt (Teillet et al., 2010) or aroma release from candies (Deleris et al., 2011; Saint-Eve et al., 2011) or drinks (Déléris et al., 2011).

1.3. The breakdown path

The purpose of this research was to examine the breakdown path of peanuts and peanut products, and to put them in the context of Hutchings and Lillford (1988) model to illustrate the oral breakdown path (Fig. 1). In this model, intact food enters the mouth towards the top left of the diagram (depending on its relative structure and moisture content). During mastication, the food structure is broken down, accompanied by an increase in degree of lubrication as saliva is secreted and mixed into the bolus. Of course the process is time dependent as both mastication and saliva production are gradual. As the oral processing proceeds, the food follows a trajectory from the top left towards the bottom right of the diagram until it enters the "swallowing bar" at which point an involuntarily swallow may occur.

By milling peanuts in a food processor we would expect to reduce the relative degree of structure, thus if milled foods are eaten they should enter Fig. 1 at a point lower on the vertical axis then the original food. According to the model it is then a matter of increasing lubrication through the mixing of saliva to form a bolus suitable to swallow.

2. Materials and methods

2.1. Sample preparation

Roasted peanuts (Love Life, Waitrose, Bracknell, UK) were purchased from local shops and then prepared into portions for mastication and swallowing as follows:

1. 4 g Portions of whole or half peanuts were dispensed into 25 cm^3 clear plastic cups.
2. Peanuts meal was produced by finely chopping the peanuts with a Robot Chef food processor equipped with a rotating blade (Robot Coupe, Vincennes, France). A particle size fraction (0.5–2 mm) was collected by feeding the milled peanuts onto a stack of two laboratory test sieves with rectangular holes (Endecotts, London, UK). The screen stack was gently shaken by hand. 4 g portions of this size fraction were dispensed into 25 cm^3 clear plastic cups.
3. Using the same food processor used to produce the peanut meal, samples of peanuts were milled until a smooth paste was achieved. The paste was transferred to a glass bowl and 4 g portions were offered to assessors in the form of a level plastic teaspoon full.

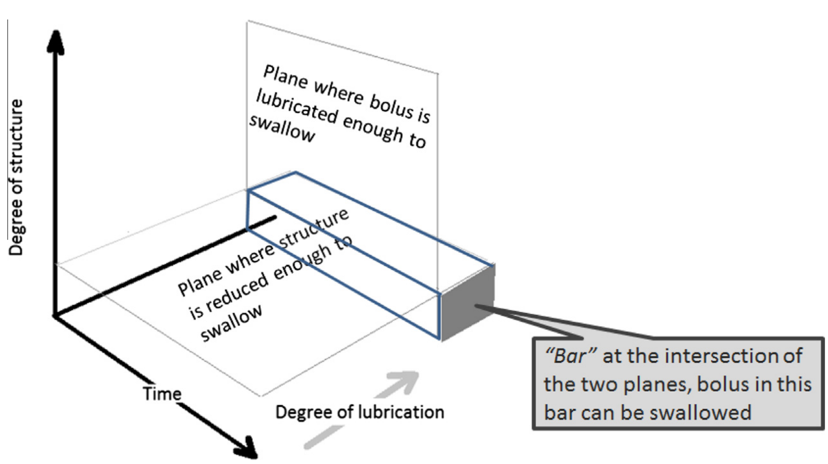

Fig. 1. Schematic to illustrate Hutchings and Lillford's "breakdown path".